

# A STANDARD OPERATING PROCEDURES MANUAL FOR THE COAST-WIDE REFERENCE MONITORING SYSTEM-*WETLANDS*:

Methods for Site Establishment, Data Collection, and Quality  
Assurance/Quality Control

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# TABLE OF CONTENTS

<b>LIST OF FIGURES .....</b>	<b>vi</b>
<b>LIST OF TABLES .....</b>	<b>ix</b>
<b>CONVERSION FACTORS, NON-SI TO SI UNITS OF MEASUREMENT .....</b>	<b>x</b>
<b>ACRONYMS/ABBREVIATIONS USED IN DOCUMENT .....</b>	<b>xi</b>
<b>ACKNOWLEDGEMENTS.....</b>	<b>xii</b>
<b>1. INTRODUCTION .....</b>	<b>1-1</b>
<b>2. SITE ESTABLISHMENT AND CONSTRUCTION.....</b>	<b>2-1</b>
2.1. Site Establishment .....	2-1
2.1.1. Methods.....	2-2
2.1.1.1. Establishing Site Location (in office).....	2-2
2.1.1.2. Selecting Site Location (in field) .....	2-4
2.1.2. Deliverables .....	2-13
2.2. Construction .....	2-14
2.2.1. Methods.....	2-15
2.2.2. Deliverables .....	2-23
<b>3. HYDROLOGIC DATA .....</b>	<b>3-1</b>
3.1. Continuous Data Collection.....	3-1
3.1.1. Instrumentation .....	3-7
3.1.2. Station Construction and Surveying.....	3-9
3.1.2.1. Open Water .....	3-9
3.1.2.2. Marsh Well .....	3-15
3.1.2.3. Floating Marsh.....	3-19
3.1.2.4. Staff Gauge Installation .....	3-25
3.1.2.5. Surveying Procedures .....	3-28
3.1.3. Initial Deployment of Continuous Recorders.....	3-36
3.1.3.1. Open Water Deployment .....	3-36
3.1.3.2. Marsh Well Deployment .....	3-40
3.1.3.3. Floating Mat Deployment.....	3-40
3.1.4. Servicing .....	3-45
3.1.4.1. Open Water Servicing .....	3-45
3.1.4.2. Marsh Well Servicing.....	3-49
3.1.4.3. Floating Mat Servicing .....	3-50
3.1.5. Data Processing .....	3-52
3.1.5.1. Processing of Open Water Data.....	3-52
3.1.5.2. Processing of Marsh Well Data .....	3-57
3.1.5.3. Processing of Floating Mat Data .....	3-57

3.1.6. Continuous Data Deliverables .....	3-62
3.1.6.1. Surveying Data.....	3-62
3.1.6.2. Open Water and Marsh Well Data .....	3-62
3.1.6.3. Floating Mat Data.....	3-62
3.2. Discrete Data Collection.....	3-63
3.2.1. Calibration.....	3-63
3.2.2. Methods for Discrete Data Collection .....	3-66
3.2.2.1. Surface Water Data Collection .....	3-66
3.2.2.2. Soil Porewater Data Collection.....	3-67
3.2.3. Discrete Data Processing and QA/QC .....	3-70
3.2.4. Discrete Data Deliverables .....	3-73
<b>4. ROD-SURFACE ELEVATION TABLE.....</b>	<b>4-1</b>
4.1. Field Station Establishment.....	4-4
4.2. Data Collection.....	4-6
4.3. Data Processing.....	4-14
4.4. Deliverables .....	4-16
<b>5. VERTICAL ACCRETION .....</b>	<b>5-1</b>
5.1. Introduction .....	5-1
5.2. Station Establishment .....	5-1
5.3. Data Collection.....	5-7
5.4. Data Processing.....	5-15
5.5. Deliverables .....	5-18
<b>6. MAINTENANCE .....</b>	<b>6-1</b>
<b>7. VEGETATION .....</b>	<b>7-1</b>
7.1. Emergent Vegetation Sampling.....	7-1
7.1.1. Methods.....	7-1
7.1.2. Data Processing .....	7-9
7.1.3. Deliverables .....	7-11
7.2. Swamp Forest .....	7-15
7.2.1 Site Design .....	7-15
7.2.2 Field Station Establishment .....	7-17
7.2.3 Field Methods.....	7-19
7.2.3.1 Canopy Layer.....	7-19
7.2.3.2 Understory Layer .....	7-24
7.2.3.3 Herbaceous Layer.....	7-24
7.2.4 Data Processing .....	7-26
7.2.5 Deliverables.....	7-28
<b>8. SOIL PROPERTIES .....</b>	<b>8-1</b>
8.1. Field Station Establishment.....	8-1
8.2. Data Collection.....	8-4
8.3. Data Processing.....	8-12
8.3.1. Laboratory Analysis .....	8-12
8.3.2. Data Entry and QA/QC .....	8-18
8.4. Deliverables .....	8-20

<b>9. IMAGERY .....</b>	<b>9-1</b>
9.1. Aerial Photography.....	9-1
9.2. Satellite Imagery .....	9-2
<b>10. REFERENCES .....</b>	<b>10-1</b>

## LIST OF FIGURES

<b>Figure 2.1.</b> The 1-km <sup>2</sup> grid of 200-m squares. ....	2-3
<b>Figure 2.2.</b> Site characterization sheet used during the preliminary site visit (PSV). ....	2-5
<b>Figure 2.3.</b> Site sketch sheet used to draw the layout of the proposed data collection area (DCA). ....	2-7
<b>Figure 2.4A.</b> Typical schematic of a base boardwalk in an attached marsh. ....	2-8
<b>Figure 2.4B.</b> Typical schematic of a base boardwalk in a floating marsh. ....	2-9
<b>Figure 2.5.</b> CRMS- <i>Wetlands</i> Site Decision Tree used to determine the placement of the 200 x 200-m site within the 1-km square. ....	2-11
<b>Figure 2.6.</b> Tooth construction diagram used to support the boardwalk for access to the data collection stations. ....	2-17
<b>Figure 2.7.</b> Typical layout schematic of the constructed site features at an attached marsh site. ....	2-19
<b>Figure 2.8.</b> Typical layout schematic of the constructed site features at a floating marsh site. ....	2-20
<b>Figure 2.9.</b> Schematic for the construction of a floating boardwalk. ....	2-21
<b>Figure 2.10.</b> Detailed schematic for construction of the float used to support the floating boardwalk. ....	2-22
<b>Figure 2.11.</b> Site construction report to be completed during the construction of each site. ....	2-24
<b>Figure 3.1.</b> Typical wooden post station. ....	3-2
<b>Figure 3.2.</b> Typical stainless steel mono-pole station. ....	3-3
<b>Figure 3.3.</b> Typical marsh well station. ....	3-5
<b>Figure 3.4.</b> Typical floating marsh mat continuous recorder station. ....	3-6
<b>Figure 3.5.</b> Typical static marsh mat continuous recorder station. ....	3-7
<b>Figure 3.6.</b> Continuous recorder water level sensor data sheet ....	3-13
<b>Figure 3.7.</b> Schematic of distances needed to be measured for elevation calculations for the wooden post continuous recorder set-up. ....	3-14
<b>Figure 3.8.</b> Detailed drawing of the inner 2" PVC well where the continuous recorder will be placed in the marsh well set-up. ....	3-17
<b>Figure 3.9.</b> Construction diagram for each individual component of the floating marsh mat recorder. ....	3-21
<b>Figure 3.10.</b> Construction drawing for the instrument housing unit used on the static marsh mat continuous recorder system ....	3-25
<b>Figure 3.11.</b> Typical staff gauge installation ....	3-27

<b>Figure 3.12.</b> Example of a surveying spreadsheet used to calculate correction factors for historical monitoring hydrologic data.....	3-30
<b>Figure 3.13.</b> Example of a continuous recorder survey data sheet.....	3-31
<b>Figure 3.14.</b> Example of a staff gauge survey data sheet.....	3-34
<b>Figure 3.15.</b> Marsh elevation survey data format .....	3-35
<b>Figure 3.16.</b> Continuous recorder calibration sheet.....	3-37
<b>Figure 3.17.</b> Static marsh mat recorder calibration sheet .....	3-44
<b>Figure 3.18.</b> Post-processing format of continuous hydrographic data.....	3-54
<b>Figure 3.19.</b> Hydrologic QA/QC checklist. ....	3-56
<b>Figure 3.20.</b> Schematic of the floating marsh mat continuous recorder set-up and the associated “reference” open water continuous recorder set-up. ....	3-58
<b>Figure 3.21.</b> Discrete hydrographic/soil porewater data sheet.....	3-65
<b>Figure 3.22.</b> Monthly hand-held salinity meter calibration data sheet.....	3-65
<b>Figure 3.23.</b> Typical soil porewater sipper .....	3-68
<b>Figure 3.24.</b> Discrete hydrographic autoloader template .....	3-72
<b>Figure 4.1.</b> Construction drawing of a surface elevation table used on a 9/16” benchmark rod (Source: Cahoon et al. 2002b). ....	4-2
<b>Figure 4.2.</b> A typical RSET data collection schematic showing nine pins used to measure marsh surface elevation. ....	4-3
<b>Figure 4.3.</b> Detailed construction drawing of a typical RSET station with collar. Inset: Collar detail. ....	4-7
<b>Figure 4.4.</b> Surface elevation table (RSET) data sheet .....	4-9
<b>Figure 4.5.</b> RSET QA/QC checklist.....	4-17
<b>Figure 4.6.</b> Post-processing format of RSET data. ....	4-18
<b>Figure 5.1.</b> Schematic of the accretion stations around an attached marsh site.....	5-3
<b>Figure 5.2.</b> Typical establishment and sampling (short-term and long-term) schedule for accretion stations. ....	5-4
<b>Figure 5.3.</b> Schematic for the cryogenic coring device developed by Cahoon et al. 1996 .....	5-9
<b>Figure 5.4.</b> Example of a vertical accretion (VA) field data sheet. ....	5-11
<b>Figure 5.5.</b> QA/QC checklist .....	5-17
<b>Figure 5.6.</b> Accretion data format in .csv file and SONRIS. ....	5-18
<b>Figure 7.1.</b> Herbaceous marsh vegetation sampling data sheet printout from electronic digital format.....	7-7

<b>Figure 7.2.</b> Herbaceous swamp vegetation sampling data sheet printout from electronic digital format.....	7-8
<b>Figure 7.3.</b> Herbaceous vegetation data format .....	7-12
<b>Figure 7.4.</b> Soil porewater format at emergent vegetation stations .....	7-13
<b>Figure 7.5.</b> Emergent vegetation QA/QC checklist .....	7-14
<b>Figure 7.6.</b> Illustration of swamp site design and layout (not to scale) .....	7-16
<b>Figure 7.7.</b> Illustration of the naming convention for swamp stations and their nested understory stations.....	7-18
<b>Figure 7.8.</b> Field data sheet for the canopy layer data, which include species composition, tree diameter measurements, and densiometer measures. ....	7-21
<b>Figure 7.9.</b> Examples of proper values given to canopy cover in one square of the densiometer. ....	7-23
<b>Figure 7.10.</b> Field data sheet for the understory layer, which includes woody shrubs and sapling trees < 5 cm diameter at breast height. ....	7-25
<b>Figure 7.11.</b> Forest canopy and understory layer data format. ....	7-29
<b>Figure 8.1.</b> Typical specifications of a core extracting device (modified from Meriwether et al. 1996 and Phillips 2002). ....	8-2
<b>Figure 8.2.</b> Diagram of CRMS site boardwalk area and the area available for sediment sample collection.....	8-3
<b>Figure 8.3.</b> Typical construction diagram for the soil core extruder (redrawn from Phillips (2002). ....	8-5
<b>Figure 8.4.</b> Soil cores data sheet. ....	8-6
<b>Figure 8.5.</b> Chain of custody form.....	8-7
<b>Figure 8.6.</b> Soil core data format .....	8-21
<b>Figure 8.7.</b> Example of a soil cores data QA/QC checklist .....	8-22



## LIST OF TABLES

<b>Table 2.1.</b> Materials list for the base boardwalks (Figures 2.4A and 2.4B) .....	2-15
<b>Table 3.1.</b> Conductivity, salinity, and temperature range and accuracy minimum standards for the hand-held water quality units.....	3-9
<b>Table 3.2.</b> Total instrument length (ft) and distance from bottom to depth sensor (ft) for the most commonly used continuous recorder models .....	3-49
<b>Table 7.1.</b> Vegetative cover values associated with the Braun-Blanquet method.....	7-9
<b>Table 8.1.</b> Soil parameters to be measured by the lab and their associated units with acceptable ranges.....	8-19

## CONVERSION FACTORS, NON-SI TO SI UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric units) as follows:

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
acres	0.4047	hectares
Fahrenheit degrees	5/9	Celsius degrees <sup>1</sup>
feet	0.3048	meters
inches	2.54	centimeters
miles (U.S. statute)	1.6093	kilometers
square inches	6.4516	square centimeters

<sup>1</sup>To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula:  $C = (5/9) (F-32)$ .

## ACRONYMS/ABBREVIATIONS USED IN DOCUMENT

Acronym/Abbreviation	Term/Concept it Represents
CCA	chromate copper arsenate
CPRA	Coastal Protection and Restoration Authority
CR	continuous recorder
CRMS	Coast-wide Reference Monitoring System- <i>Wetlands</i>
CWPPRA	Coastal Wetlands Planning, Protection, and Restoration Act
DBH	diameter at breast height
DCA	data collection area
DGPS	Differential Global Positioning System
DOQQ	digital orthophoto quarter-quadrangles
EC	soil salinity
GPS	Global Positioning System
LCZ	Louisiana Coastal Zone
LRS	Land Rights Section
NAD83	North American Datum, 1983
NAVD88	North American Vertical Datum, 1988
NWRC	National Wetlands Research Center
CPRA	Coastal Protection and Restoration Authority
PSV	preliminary site visit
RSET	Rod-Surface Elevation Table
RTK	real-time kinematic
SET	Surface Elevation Table
SM	secondary monument
SPOT	Système Pour l'Observation de la Terre (French remote sensing satellite)
TBM	temporary benchmark
VA	vertical accretion
UTM	Universal Transverse Mercator coordinate system

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# 1. INTRODUCTION

Coastal Louisiana is experiencing a loss of more than 15 square miles of land per year. Since the 1930's, over 1,883 square miles of valuable wetland habitat have disappeared (Couvillion et al. 2011). In response to this loss, a multi-agency task force, comprised of federal and state government sponsors, created the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) of 1990 to conserve, restore, create, or enhance coastal wetlands. Through CWPPRA and various other funding sources, the Louisiana Coastal Protection and Restoration Authority (CPRA) maintains a monitoring program with the mission of providing ecological data and research to support the planning, design, construction, evaluation, and adaptive management of Louisiana's wetland restoration projects.

In 2004 the Coast-wide Reference Monitoring System-*Wetlands* (CRMS) was implemented to improve the monitoring program's capability to evaluate the effectiveness of individual restoration projects, as well as the combined effects of multiple projects, by providing a network of reference sites to compare to project sites (Steyer et al. 2003). Because CRMS was designed to determine the ecological condition of all Louisiana wetlands, not just those affected by projects, CRMS also provides the opportunity to evaluate whether whole ecosystems are being restored. Thus, the effectiveness of landscape-scale restoration strategies can also be determined.

The main purpose of this manual is to provide standardization of the scientific methods and quality control procedures used by the CPRA monitoring program and its contractors in order to produce high-quality, scientifically defensible data (Bass et al. 2003). In addition, it provides guidance for establishing, constructing, and maintaining CRMS field stations. This manual replaces Folse and West (2005) and its subsequent revision from August 2006, which included addenda 1–5. Even though the intended use of these methods and protocols is for CRMS, many of the same methods can be used in smaller-scale, more focused monitoring efforts related to specific restoration projects (i.e., project-specific monitoring).

## 2. SITE ESTABLISHMENT AND CONSTRUCTION

### 2.1 Site Establishment

The basic design of a typical CRMS site includes a 1-km<sup>2</sup> site, which serves as the boundary for land/water analysis and for the establishment of a 200-m<sup>2</sup> data collection area (DCA).

The procedure below is described with the assumption that the 1-km<sup>2</sup> CRMS site has already been randomly selected by a Geographical Information System (GIS) software program and is ready for a preliminary site visit (PSV), the purpose of which is to:

- A. determine the location of a 200-m<sup>2</sup> DCA within the 1-km<sup>2</sup> site;
- B. verify marsh community type according to Visser and Sasser (1998) within the 200-m<sup>2</sup> DCA;
- C. determine the station type and layout within the 200-m<sup>2</sup> DCA;
- D. document the logistics needed to access the site.

The general procedure is to investigate the site in the office using GIS software and site-specific documents (e.g., land rights and access agreements) to choose a number of potential locations for the DCA. This is done to make the field portion of the PSV more efficient. Field procedures consist of verifying the parameters above and making the final DCA selection.

**ACCESS AND LAND RIGHTS AGREEMENTS:** Travel logistics and proposed site locations can be found in the land rights packet supplied by the Land Rights Section (LRS) of the Coastal Protection and Restoration Authority (CPRA). The land rights packet includes a list of landowners and their contact information, site restrictions, directions to the site, and maps of each site. The LRS has only acquired access permission for the suggested route, and travel should be restricted to the directions and paths outlined in the packet. The LRS provides maps such as digital orthophoto quarter-quadrangles (DOQQ) or SPOT (Système Pour l'Observation de la Terre) imagery and Tobin plat maps. These maps provide the location of the site and the surrounding land rights. In some cases, the land rights may not be determined and/or secured at the time of the visit; however, these packages must be reviewed to confirm the secured access route. It may be advantageous to utilize the most current geo-rectified imagery to supplement the maps provided by the LRS. Using this imagery in a GIS software package will enable field personnel to look more closely at the secured access route and print out additional maps.

### 2.1.1 **Methods**

#### 2.1.1.1 ***Establishing Site Location (in office)***

1. Locate the potential CRMS site on a GIS map using the most current imagery and overlay the 1-km<sup>2</sup> grid of 200-m squares (Figure 2.1).

2. Determine if land rights are an issue.

Note: Some sites have two (2) or more landowners within the 1 km<sup>2</sup> but only one (1) landowner has signed an agreement. Therefore, the site must go on that owner's property.

A. If land rights are denied or restricted:

a. Follow landowner restrictions and proceed to step 3.

OR

b. Reselect CRMS site following established methods.

B. If land rights are accepted, proceed to step 3.

3. Determine consistency of access to the site. Can the center point of the 1 km<sup>2</sup> be consistently accessed? Is the 200-m square >55% land, and is the center point over land? Consistent access is defined by the ability to reliably reach the beginning of the access boardwalk at least once each month by a route that will cause minimum or no long-term irreversible damage to the marsh.

A. If YES to these questions, proceed to step 4.

B. If the center point cannot be consistently accessed, proceed to step 5, "Moving the 200-m square."

C. If the center of the square is not over land or the square is not >55% land, proceed to step 5, "Moving the 200-m square."

4. Determine availability of water. Is open water available in the 200-m square for the continuous recorder? Is the water characteristic of what is influencing the marsh that will be sampled? Is it hydrologically connected to the marsh?

A. If YES to these questions, use the center 200-m square. Proceed to step 5 for backup points.

B. If there is no open water, it is not characteristic, or it is not connected, proceed to step 5, "Moving the 200-m square."

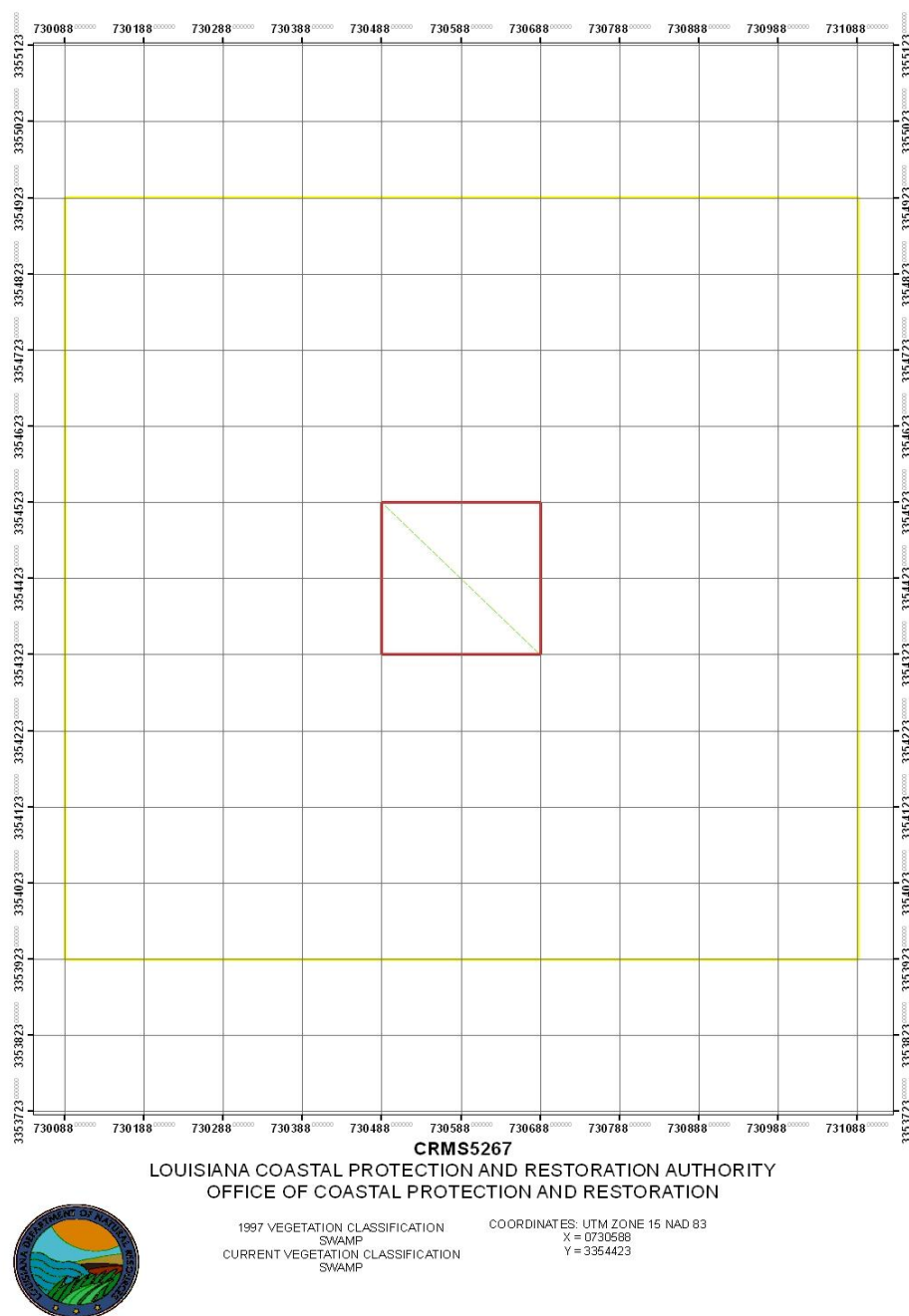
5. "Moving the 200-m square"

A. Examine the 100-m grid on the current photography.

B. Record the GPS point for the original center point of the CRMS site.

C. Select the next four possible center point locations. These center points should fall on grid nodes or be located as directed by the CPRA

## 2. Site Establishment and Construction



**Figure 2.1.** The 1-km<sup>2</sup> grid of 100-m squares. The yellow box represents the 1-km<sup>2</sup> area used to evaluate and choose a smaller 200-m<sup>2</sup> data collection area (DCA; red square). The green line represents a northwest to southeast vegetation transect.



- D. The first attempt should be to move in the four cardinal directions from the original center point. Upon selecting any potential points, follow the above decision tree.
- E. If all of these do not qualify:
  - a. The next attempt should be the diagonals connected to the original center point.
  - b. Continue outwards, selecting points that are closer to the original center first.
- F. Before a new point is accepted it must fall under the same Visser/Sasser classification as the original center point or the land that is closest to it. If the original center point is no longer the same as the listed classification, then it must be reclassified.
- G. Priorities for choosing a site are as follows:
  - 1) Same Visser/Sasser classification as the original center point
  - 2) Available water for sonde deployment
  - 3) Minimum distance to center point
- H. If points are accepted, record their GPS location data.
- I. The four new points should be in a priority list of 1–4, with 1 being the closest to the center point and proceeding outward.
- J. If a location is acceptable except for water availability, return to the grid node that is closest to the center point and use the modified well installation.
- K. If there are no acceptable 200-m squares within the 1 km<sup>2</sup>, reject and reselect the CRMS site location following established methods. STOP.

6. When proceeding to the field, take all five points that have been selected (the original center point and the four most acceptable alternates). Use these locations when scouting in case of land/marsh alterations that may have occurred since the photography was taken.

### **2.1.1.2      *Selecting Site Location (in field)***

During the site visit, field personnel should complete the “Site Characterization Sheet” (Figure 2.2) and “Site Sketch Sheet” (Figure 2.3), and photograph the area. The information/data sheet will characterize the proposed site to determine if the site is suitable for the project’s overall goals and objectives. This information can also be used in the event that a site is completely destroyed and must be reestablished.

Landowners should be contacted and permission to access granted prior to any site visit. Field personnel should approach the site with great care to maintain site and future data integrity. In some areas, depending on accessibility, additional boardwalk (access boardwalk) may be needed to continually access the base boardwalk, which starts at the center point (Figure 2.4A and 2.4B).

## 2. Site Establishment and Construction

<b>Site Characterization Sheet (Page 1 of 2)</b>																																			
Site: _____			Basin: _____																																
Date and Time (CST) of Site Visit: _____			Agency: _____																																
Field Personnel: _____																																			
Weather: _____																																			
<div style="border: 1px solid black; padding: 5px;"> <b>1. Site Location and Access:</b> <div style="float: right; text-align: right; margin-right: 20px;"> Easting: <input style="width: 100px;" type="text"/>  Northing: <input style="width: 100px;" type="text"/> </div> <div style="clear: both;"></div> <div style="margin-bottom: 5px;">Site Coordinates (Center Point; UTM, NAD83 Meters)</div> <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> Access: Nearest City: _____  Boat Ramp: _____  Type of Water Vessel: _____  Directions from field office: _____  _____  _____  Direction from boat ramp to site: _____  _____  _____  Site Restrictions: _____  Location of Secondary Benchmark: _____  Other: _____ </div> <div style="width: 45%;"> Highway Access: _____ </div> </div> </div>																																			
<div style="border: 1px solid black; padding: 5px;"> <b>2. Continuous Recorder Details:</b> <div style="float: right; text-align: right; margin-right: 20px;"> Easting: <input style="width: 100px;" type="text"/>  Northing: <input style="width: 100px;" type="text"/> </div> <div style="clear: both;"></div> <div style="margin-bottom: 5px;">Coordinates of Location (UTM, NAD 83 Meters)</div> <div style="margin-bottom: 5px;">Recommended Set-up (Wooden post, Mono-pole, Well): _____</div> <div style="margin-bottom: 5px;">Description of area [describe water body (size, depth, consistency of bottom), distance from edge, salinity]: _____</div> </div>																																			
<div style="border: 1px solid black; padding: 5px;"> <b>3. Boardwalk Details:</b> <div style="float: right; text-align: right; margin-right: 20px;"> Easting: <input style="width: 100px;" type="text"/>  Northing: <input style="width: 100px;" type="text"/> </div> <div style="clear: both;"></div> <div style="margin-bottom: 5px;">Coordinates of Access Point (UTM, NAD83 Meters)</div> <div style="margin-bottom: 5px;">Direction/Bearing of Boardwalk (degrees) _____</div> <div style="margin-bottom: 5px;">Approximate length of Access (Additional) Boardwalk (ft) _____</div> </div>																																			
<div style="border: 1px solid black; padding: 5px;"> <b>4. Site Layout Details:</b> (airboat access direction, vegetation transect orientation, RSET location, etc)  _____  _____  _____  _____ </div>																																			
<div style="border: 1px solid black; padding: 5px;"> <b>5. Photos:</b> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center; width: 15%;">Number</th> <th style="text-align: center; width: 15%;">Direction</th> <th style="text-align: center; width: 15%;">Time Stamp</th> <th style="text-align: center; width: 15%;">Number</th> <th style="text-align: center; width: 15%;">Direction</th> <th style="text-align: center; width: 15%;">Time Stamp</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">_____</td> <td style="text-align: center;">N</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td style="text-align: center;">_____</td> <td style="text-align: center;">E</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td style="text-align: center;">_____</td> <td style="text-align: center;">S</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td style="text-align: center;">_____</td> <td style="text-align: center;">W</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> </tbody> </table> </div>						Number	Direction	Time Stamp	Number	Direction	Time Stamp	_____	N	_____	_____	_____	_____	_____	E	_____	_____	_____	_____	_____	S	_____	_____	_____	_____	_____	W	_____	_____	_____	_____
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**Figure 2.2.** Site characterization sheet used during the preliminary site visit (PSV).

<b>Site Characterization Sheet (Page 2 of 2)</b>	
Site: _____	Basin: _____
Date and Time (CST) of Site Visit: _____	Agency: _____
<b>6. Vegetation:</b> Dominant Species: _____ _____ Current Marsh Type: _____ Visser/Sasser Marsh Type: _____	
<b>7. Marsh Characteristics:</b> Other Species Present: _____ _____ _____ Vegetation Characteristics (average height, grazing, burning, herbivory, wrack deposition, etc): _____ _____ _____ Marsh Stability (brokenness, soil consolidation, edge shearing): _____ _____ _____ Water on Marsh (depth, salinity): _____ _____ Other: _____ _____ _____	
<b>8. Floating Marsh:</b> Recommended Set-up (Floating or Static): _____ Mat thickness (ft): _____ Distance from mat surface to firm substrate: _____ Mat characteristics: _____	
<b>9. Potential Site Problems:</b> _____ _____ _____ _____	

**Figure 2.2 (cont.).** Site characterization sheet used during the preliminary site visit (PSV).

## 2. Site Establishment and Construction

**Site Sketch Sheet**

CRMS Site: \_\_\_\_\_ Center Coordinates: Easting \_\_\_\_\_  
 Date & Time: \_\_\_\_\_ Northing \_\_\_\_\_  
 Personnel: \_\_\_\_\_

**N**

200 m

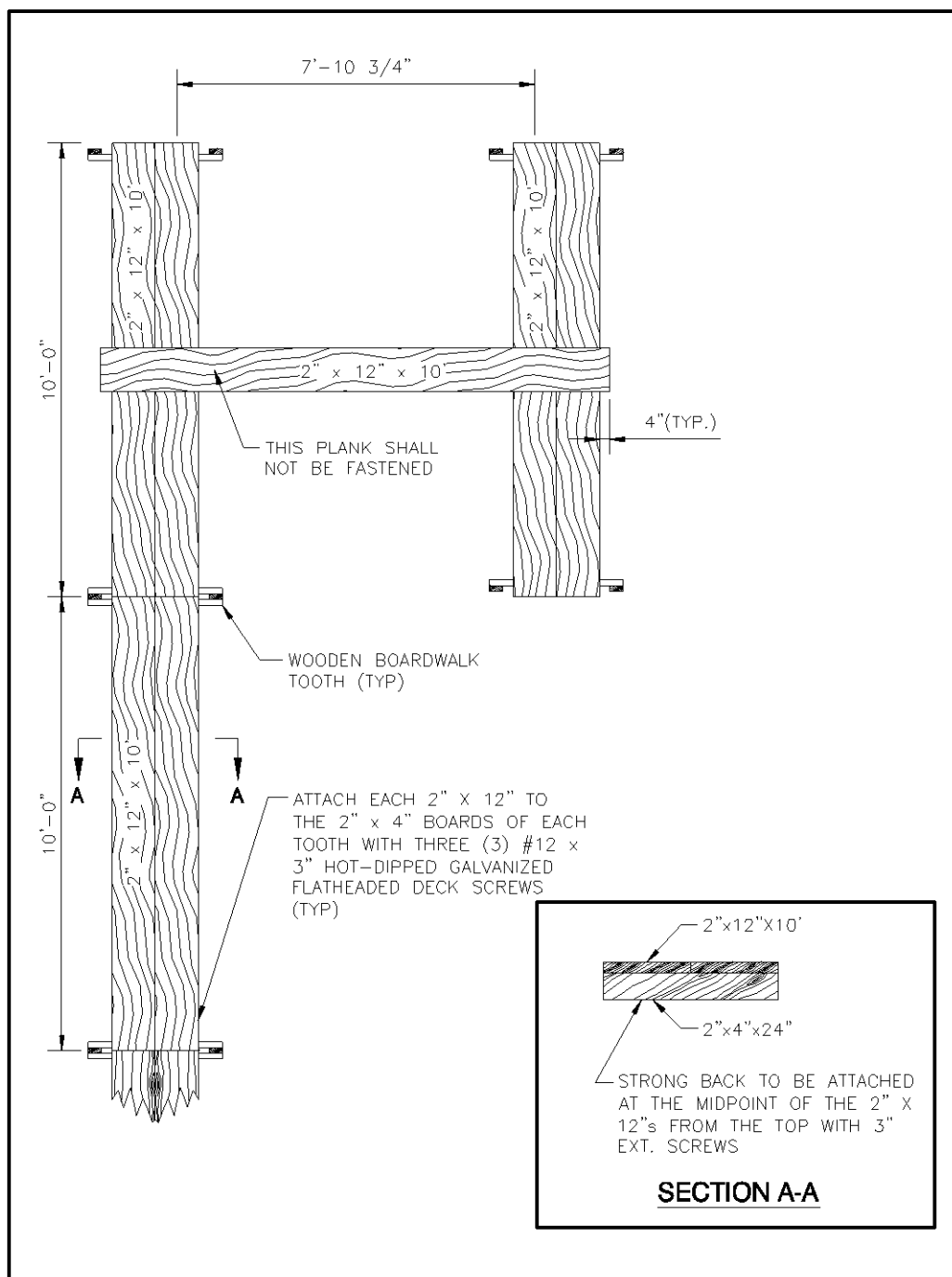
200 m

**S**

Site Description: (Location and orientation of access route, boardwalk, SET, continuous recorder, and vegetation transect)

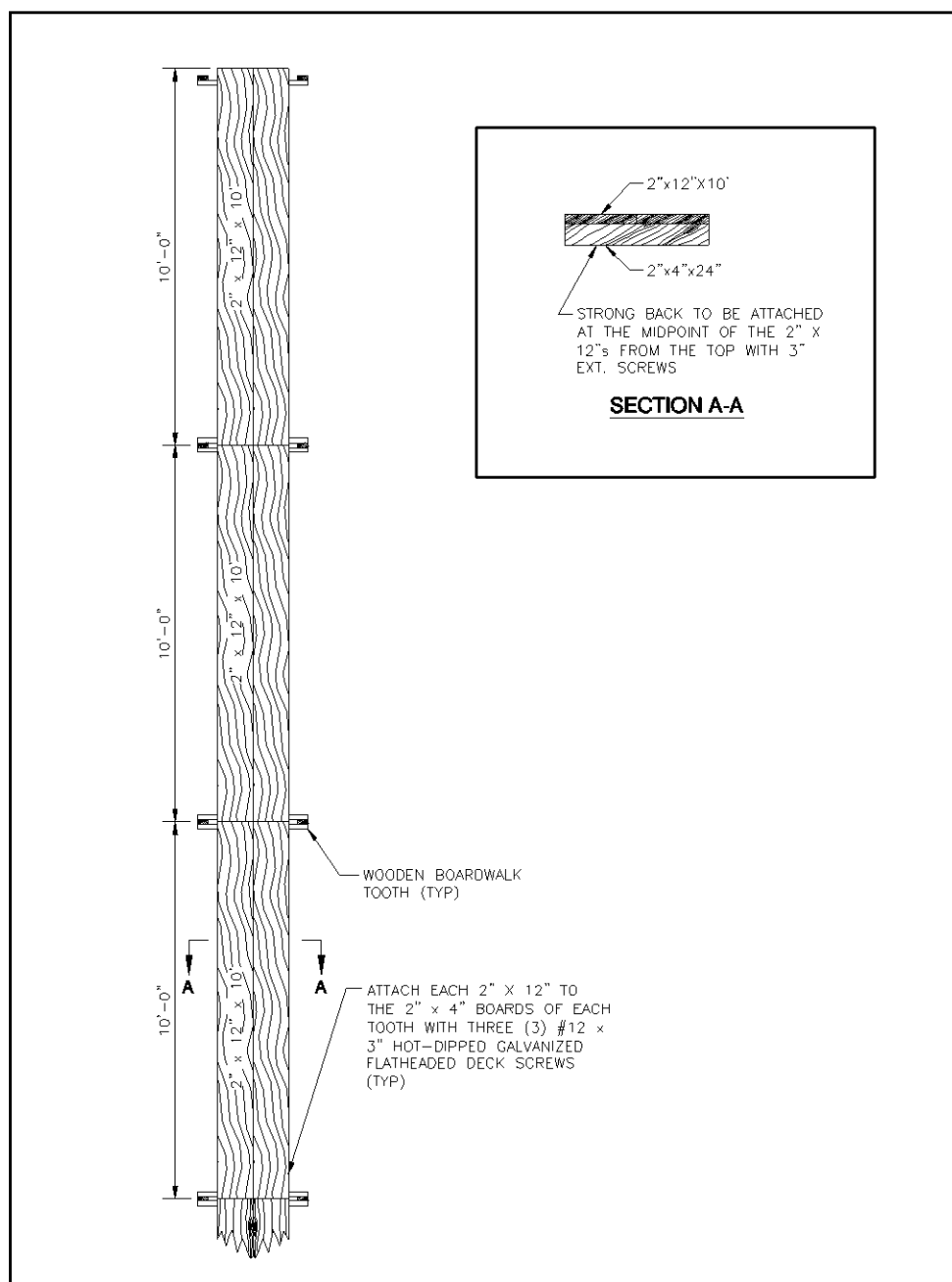
<p><u>Checklist</u></p> <p><input type="checkbox"/> Compass</p> <p><input type="checkbox"/> Camera</p> <p><input type="checkbox"/> GPS</p> <p><input type="checkbox"/> Survey Rod</p> <p><input type="checkbox"/> Permanent Marker</p>	<p>Notes:</p>	<p><b>LEGEND</b></p> <p>△ - Access Point</p> <p>● - Center Point</p> <p>▲ - Marsh Well</p> <p>⊗ - RSET</p> <p>■ - Continuous Recorder</p> <p>— — Vegetation Transect</p> <p>→ Access Route</p> <p><b>AB</b> - Access Boardwalk</p> <p><b>BB</b> - Base Boardwalk</p>
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**Figure 2.3.** Site sketch sheet used to draw the layout of the proposed data collection area (DCA).



**Figure 2.4A.** Typical schematic of a base boardwalk in an attached marsh.

## 2. Site Establishment and Construction



**Figure 2.4B.** Typical schematic of a base boardwalk in a floating marsh.

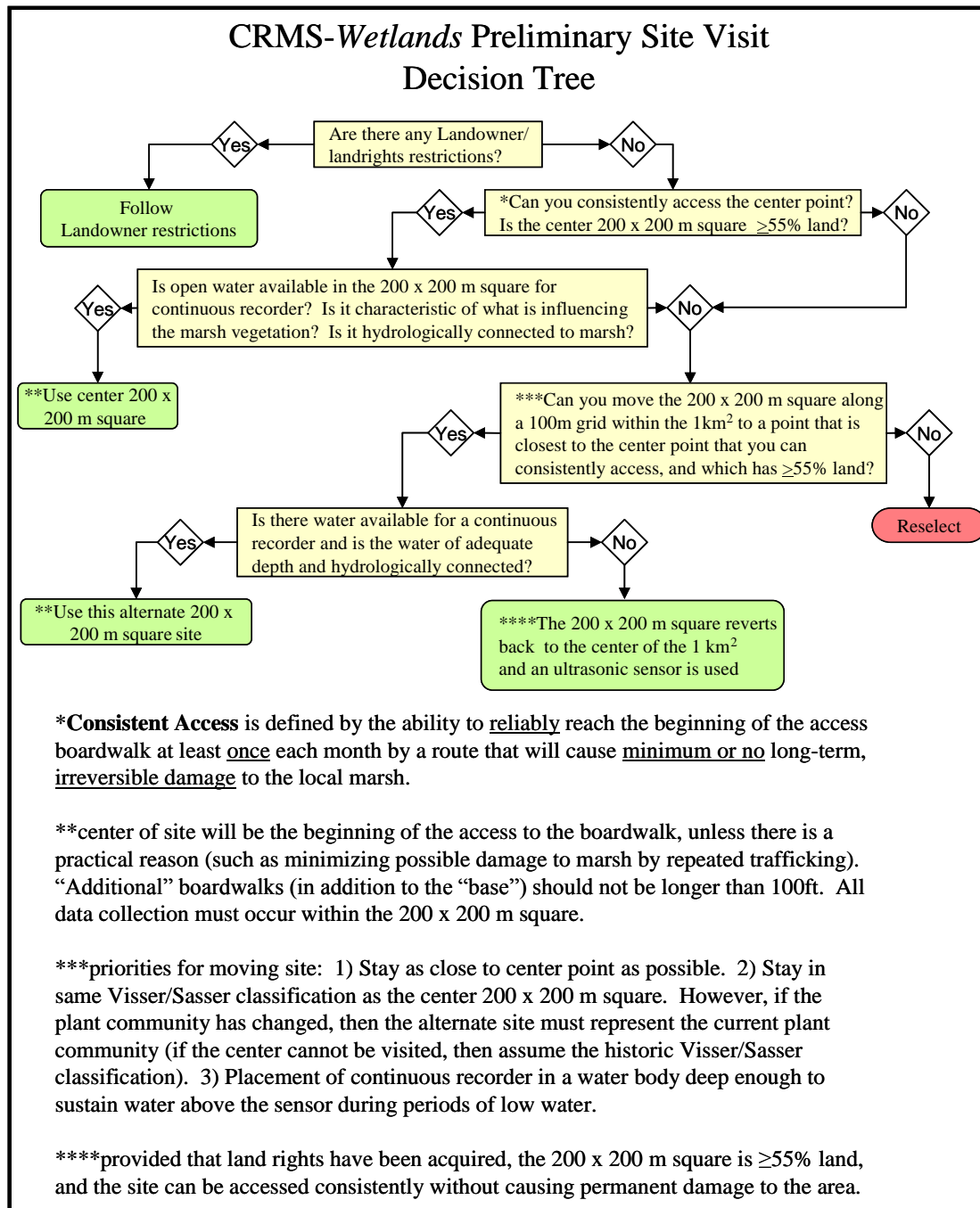
The following section provides a list of the minimum materials/equipment necessary to perform an adequate preliminary site visit and evaluation.

### *Materials:*

1. Compass: 0° to 360° azimuth dial with 2° graduations
2. Digital camera with date stamp capabilities
3. Measuring tape: capable of measuring 100 m (~328.1 ft)
4. Differential Global Positioning System (DGPS) unit: capable of real-time correction
5. Maps
6. "Site Characterization Sheet" (Figure 2.2)
7. "Site Sketch Sheet" (Figure 2.3)
8. Pencils and pens
9. PVC poles to mark locations for infrastructure installation (e.g., boardwalk(s), continuous recorders)
10. Soil corer for floating marshes
11. Survey rod
12. Salinity meter

The following steps describe specific procedures necessary to select a site location in the field:

1. Using the LRS land rights packet, GPS coordinates, and/or other maps, travel to the center of the 200 x 200-m square site (center point), if logistically possible. Be careful not to damage the site and compromise future data.
2. Using the CRMS-*Wetlands* Preliminary Site Visit Decision Tree (Figure 2.5), determine if the proposed 200 x 200-m site is sufficient for the goal of the project. If the site is sufficient for the goal of the project, then continue to collect the necessary information needed to complete the "Site Characterization Sheet." If the 200 x 200-m site is not sufficient, continue using the decision tree until a site is selected. The site shall be moved in 100-m increments away from its original position while trying to keep it close to the center of the 1-km square, within the same vegetation community, and having a water body that is deep enough to continually submerge the sensors during periods of low water. Once a site has been selected, complete the "Site Characterization Sheet."



**Figure 2.5.** CRMS-Wetlands Site Decision Tree used to determine the placement of the 200 x 200-m site within the 1-km square.



## 2. Site Establishment and Construction

- A. Use the DGPS unit to document the coordinates of the center point (the beginning of the base boardwalk, if the center point is relocated) and the beginning of the access boardwalk if applicable. Record the GPS coordinates (in UTM [Universal Transverse Mercator coordinate system], NAD83 [North American Datum of 1983], meters). Determine the bearing (in degrees) of the boardwalk from the access point (the access point is the center point if there is no access boardwalk and the beginning of the access boardwalk if there is one). Determine the approximate length (in feet) that the boardwalk will extend, if there will be an access boardwalk. Document this in Section 3 of the "Site Characterization Sheet."

Note: The maximum distance of access boardwalk is 100 ft.

Note: PVC markers may be left at the site to mark the exact location; however, enough descriptive information should be obtained to not rely solely on the markers. It is possible that the markers may be removed by others before construction of the site begins.

Note: Sites accessed with airboats shall have a 10-ft access boardwalk to prevent or reduce the chances of damage occurring to the data collection stations.

3. Determine the orientation of the vegetation transect, northwest to southeast or northeast to southwest, and document the decision in Section 4 of the "Site Characterization Sheet." If the transect can be placed in either direction, its orientation should be decided randomly (using flip of a coin or some other random method). Vegetation transects should not parallel any geologic feature, human-induced feature (e.g., spoil banks), or a uniform vegetation community. The objective of the vegetation transect is to characterize the entire plant community within the site.
4. At the center point, take a few pictures from an elevated position in various directions (N, E, S, and W) to provide a reference prior to site construction. Note each picture's number, direction, and time stamp in Section 5 of the "Site Characterization Sheet."
5. Record the dominant vegetation species of the site in Section 6 of the "Site Characterization Sheet" and characterize the marsh condition (e.g., any notable ecological/biological attributes, evidence of nutria herbivory, noticeable causes of degradation such as saltwater intrusion, etc.) in Section 7.
6. If the site is a floating marsh, then the marsh mat must be cored to determine its thickness and the depth from the surface to the firm clay layer below the mat. Document these measurements in Section 8 of the "Site Characterization Sheet." Describe any other characteristics of the mat that may be beneficial for construction and/or historical records.
7. Briefly describe any potential problems that may arise during initial site construction or during routine sampling of the site and make any recommendations for subsequent site visits in Section 9 of the "Site

- Characterization Sheet.” Also, if the center point of the 1 km<sup>2</sup> is not being used, then document the reason for moving the center point and the justification for the new center point.
8. Before leaving the site, sketch the major landscape features such as ponds, waterways, marsh/swamp, etc. (Figure 2.3) within the 200 x 200-m square, and any other important features that would assist the construction crew in identifying the proper location for the station to be constructed. Also sketch the layout of the boardwalk and placement of stations within the square in the proper directions. Any features that are outside of the square that are relevant to the site should be placed outside of the square on the sketch.
  9. Determine the best location for the continuous recorder. Document the coordinates for its location, recommend the type of set-up needed to deploy the instrument, and describe the location (size and depth of the water body, consistency of the bottom, distance from edge of emergent vegetation, etc.). When determining the location for a continuous salinity and water level recorder, it is imperative that the water body maintains a depth that will continually submerge the sensor during periods of low water, especially during the winter months.

Upon return from the PSV, GIS software should be used to upload the DGPS coordinates for all points that were collected in the field. A map should be produced showing the site layout and locations of the sampling stations to facilitate the construction phase.

### 2.1.2 **Deliverables**

The deliverable will be a single PDF per site that is created from several sources:

1. The field-completed “Site Characterization Sheet” (Figure 2.2) shall be transcribed into the Excel file used in the site selection process along with any other pertinent information obtained from the field or during the site location selection process. The Excel file shall then be converted to a PDF.
2. All downloaded pictures (jpeg images) from the field shall be viewed and the file names shall be renamed to describe the site number and direction and date of the picture (e.g., CRMS0395\_N\_03112004.jpg). The pictures shall be inserted into the PDF.
3. The field-completed “Site Sketch Sheet” (Figure 2.3) shall be scanned and saved as a PDF. The scanned copy shall then be inserted into the PDF containing items from 1 and 2 above.
4. A layout map shall be created of the 1-km<sup>2</sup> area to a scale of 1:6,000 that shows the location of the 200-m square, the continuous recorder, orientation of the vegetation transect, the access boardwalk, and the base boardwalk. The map shall also include a north arrow, scale bar, site number, imagery information, and a unique map identification number for reproduction. The map shall be inserted into the PDF.

5. A route map shall be prepared that shows the route to be taken from the landing to the site or from another site near-by. The map shall also include a north arrow, scale bar, site number, imagery information, and a unique map identification number for reproduction. The map shall be inserted into the PDF.
6. The original field "Site Characterization Sheet" shall be scanned and inserted at the end of the PDF.

**APPROVAL:** Once the PSV deliverable is received, it will be reviewed by the CPRA. The CPRA will review the land rights information, location, and site logistics. The PSV information will then be sent to the landowner for approval of the final site location. Once the PSV is approved by the CPRA and the landowner, the contractor will be given permission to begin construction of the boardwalk.

### 2.2 Construction

#### *Materials:*

All wooden materials used to construct the boardwalk or data collection stations (listed in Table 2.1) shall consist of pressure-treated materials or equivalent. All treated material used for the construction of data collection sites for the CPRA shall consist of the chromate copper arsenate (CCA) preservative, which is the only preservative recommended for brackish and saltwater usage. The lumber industry treats the raw wood using three levels of retention: 0.6 pounds per cubic foot (pcf) for salt splash, 0.8 pcf for brackish water environments, and 2.5 pcf for saltwater environments. When calculating the quantity of materials needed and the levels of retention required, the CPRA requires the following retention levels: (1) materials being placed into the soil and/or water in a brackish or saline environment shall be treated with the maximum level of retention, i.e., 2.5 pcf for saltwater environments, and (2) materials being used for decking (2" x 12") and all material being used in freshwater environments shall be treated with a 0.6 pcf rating for salt splash.

**Table 2.1.** Materials list for the base boardwalks (Figures 2.4A and 2.4B).

<b>Material Type</b>	<b>Quantity for Attached Marsh</b>	<b>Quantity For Floating Marsh</b>
2" x 4" x 24" treated board	15	12
2" x 4" x 8-ft treated board	10	8
2" x 12" x 10-ft treated board	7	6
3/8" x 4" hot-dipped galvanized bolt	10	8
3/8" x 6" hot-dipped galvanized bolt	10	8
3" hot-dipped galvanized wood screws	36	36

Recommended tools for construction include: hand saw or skill saw to cut boards, cordless drill with various size wooden bits and screwdriver heads, crescent wrenches, socket wrenches, sledgehammer, tape measure, gloves, and hammer. Note: Personnel protection equipment shall be worn during all phases of material handling.

### 2.2.1 **Methods**

The main part of the boardwalk platform is called a tooth and it comprises two (2) legs (2" x 4" x 8 ft or 10 ft) attached to three (3) crosspieces with the hot-dipped galvanized carriage bolts. This part of the boardwalk can be assembled before constructing the boardwalk in the field. If the water vessel is not large enough to safely handle the assembled teeth, it is highly recommend that the teeth be disassembled. A typical tooth construction is found in Figure 2.6.

Using the CPRA-approved "Preliminary Site Visit" (PSV) deliverable packet, enter the 200 x 200-m site using the pre-determined route access. When accessing the area for the base boardwalk construction, a 10-m (32.8-ft) buffer zone shall be observed. In this buffer zone, there shall be neither airboat travel nor any foot traffic except at the point of accessing the boardwalk. Once the access point has been established, there shall be no access from the other side of the boardwalk. The boardwalk shall be accessed from the same location during every site visit. This will ensure that the site will not be compromised by the construction personnel or any personnel visiting the site for future data collection efforts. Other stations will be established adjacent to the boardwalk; therefore, the access route must be followed at all times. Upon arrival at the access

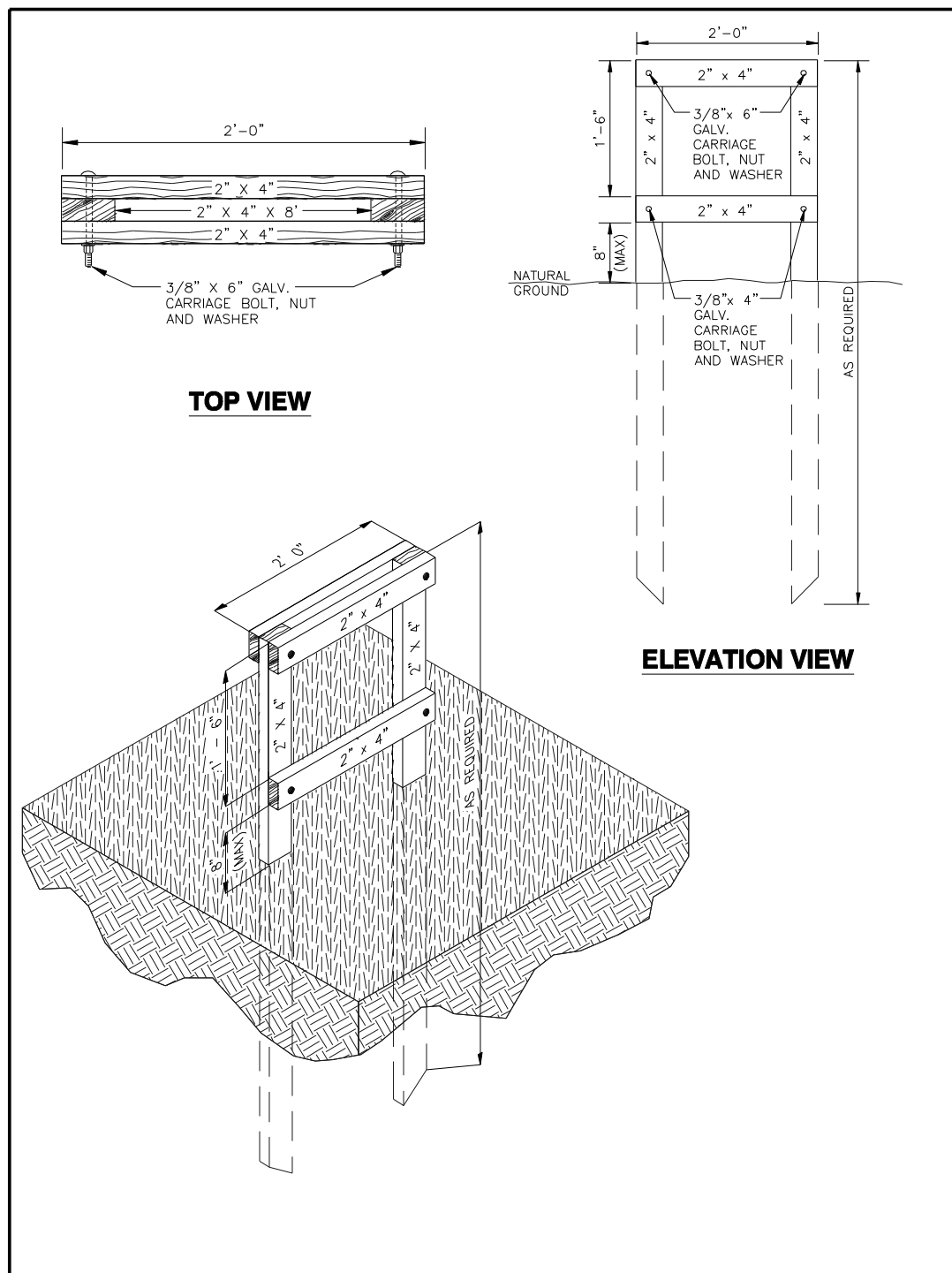
point of the boardwalk, the construction personnel shall begin the construction of the boardwalk from the water vessel. This will prevent any disturbance to the site.

The following procedures shall be followed to assure proper installation without damaging the marsh or swamp surface.

1. Using the approved PSV deliverable packet, the construction crew shall arrive at the coordinates designated for the beginning of the boardwalk (access point).
2. Determine the orientation/direction of the boardwalk from the water vessel using the provided information.
3. Place the sharpened end of the tooth onto the marsh/swamp surface.
4. Using the weight of the person installing the tooth, drive the tooth into the surface of the marsh/swamp. Note: To facilitate the installation, the four 3/8" carriage bolts should be loosened to allow the legs to penetrate into the marsh surface independently.
5. The bottom support piece shall rest on the marsh surface or to a maximum of eight (8) inches above the surface.
6. Tighten all four carriage bolts once the tooth has been driven to the proper position above the marsh surface. This shall secure the tooth from any horizontal movement.
7. Once the tooth has been installed, lay one end of a 2" x 12" x 10-ft board on the tooth (preferably on the cross piece closest to the marsh surface) with the other end placed on the marsh where the next tooth will be installed.
8. Standing on the end of the board and not on the surface of the marsh, install the next tooth.
9. Place two 2" x 12" x 10-ft boards between the two teeth. Secure the boards to the teeth using the 3" screws. Note: Decisions may be made to leave only a portion or none of the boards in place to reduce the risk of vandalism.
10. Repeat steps 3 through 9 until the boardwalk is constructed to the desired length.

Due to the span length (10 ft) with no support, the 2" x 12" boards need to be connected by using a small piece of 2" x 4" board (see insert on Figures 2.4A and 2.4B). This prevents the boards from flexing separately and reduces the flexibility of the boards, providing for a more stable platform to traverse.

## 2. Site Establishment and Construction



**Figure 2.6.** Tooth construction diagram used to support the boardwalk for access to the data collection stations.

## 2. Site Establishment and Construction

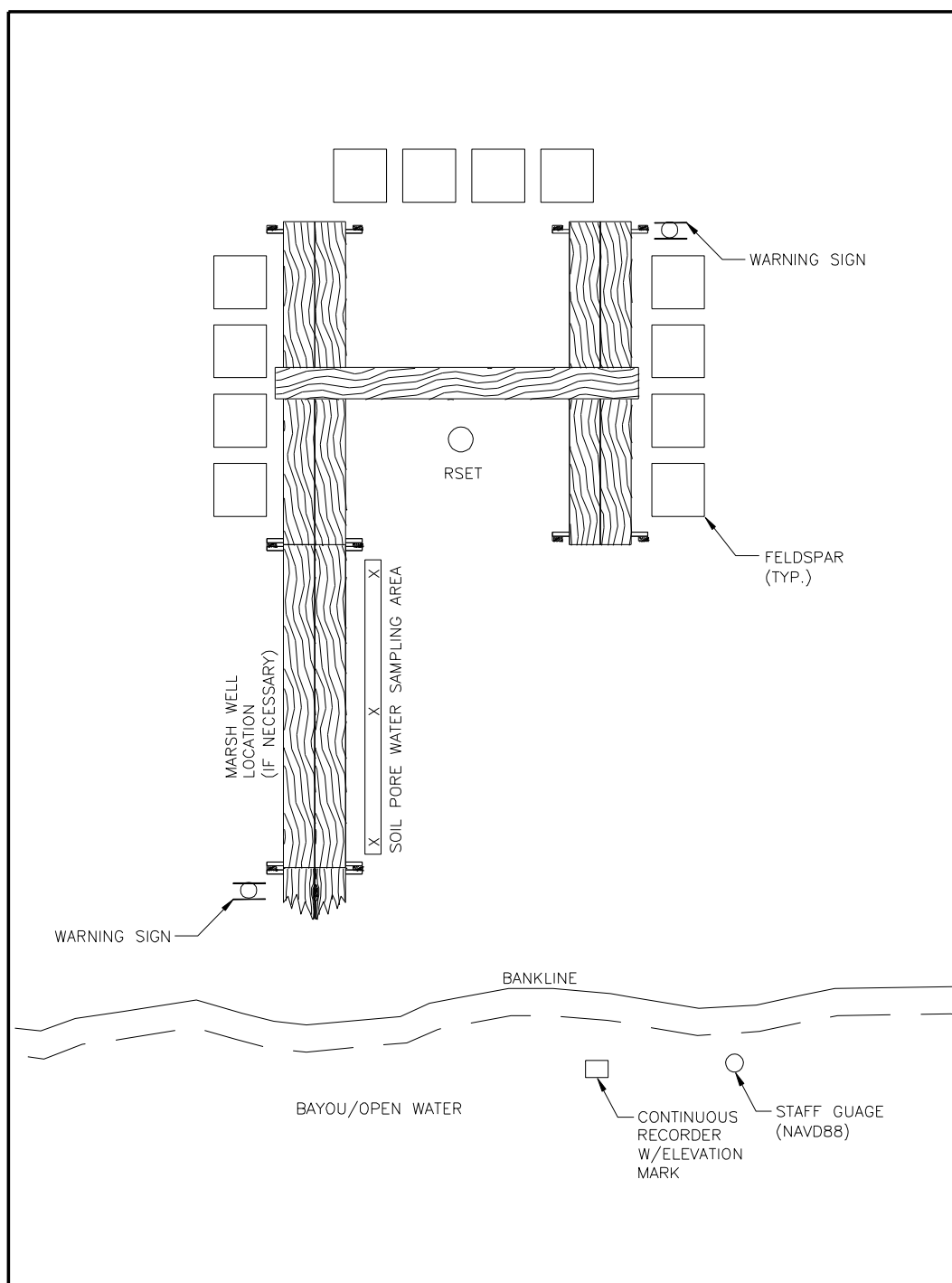
When constructing base boardwalk in an attached marsh or swamp, a 10-ft boardwalk shall be constructed parallel to the previously constructed 20-ft section on either side. The PSV deliverable packet instructs the placement of the 10-ft boardwalk.

1. From the middle tooth of the base boardwalk (2<sup>nd</sup> tooth from the end) place a 2" x 12" x 10-ft board perpendicular to the boardwalk on the appropriate side of the marsh/swamp surface.
2. Place the tooth such that the inside of the tooth is approximately 7.5 ft from the tooth of the constructed boardwalk. Orient the tooth such that the 10-ft section will parallel the longer section.
3. Construct the boardwalk following steps 3–9. The end product shall resemble Figure 2.7.

In a floating marsh, the boardwalk will be one long boardwalk with no flanking boardwalk, since these sites do not have rod-surface elevation table (RSET) stations. The end product shall resemble Figure 2.8. The 30-ft base boardwalk will be similar to an attached boardwalk; however, an extra 10 ft will be added off the end of the base boardwalk. These 10 ft of boardwalk will be free of any teeth and will float on top of the marsh surface. A detailed schematic of the floating system can be seen in Figures 2.9 and 2.10.

During the construction of the site, no one should walk on the surface of the marsh/swamp at any time. The integrity of the data that will be collected at a later date depends on the wetland functioning naturally in an undisturbed manner. Failure to follow this guideline will result in the construction of another site at another location at the expense of the contractor. The replacement site would be determined by the CPRA.

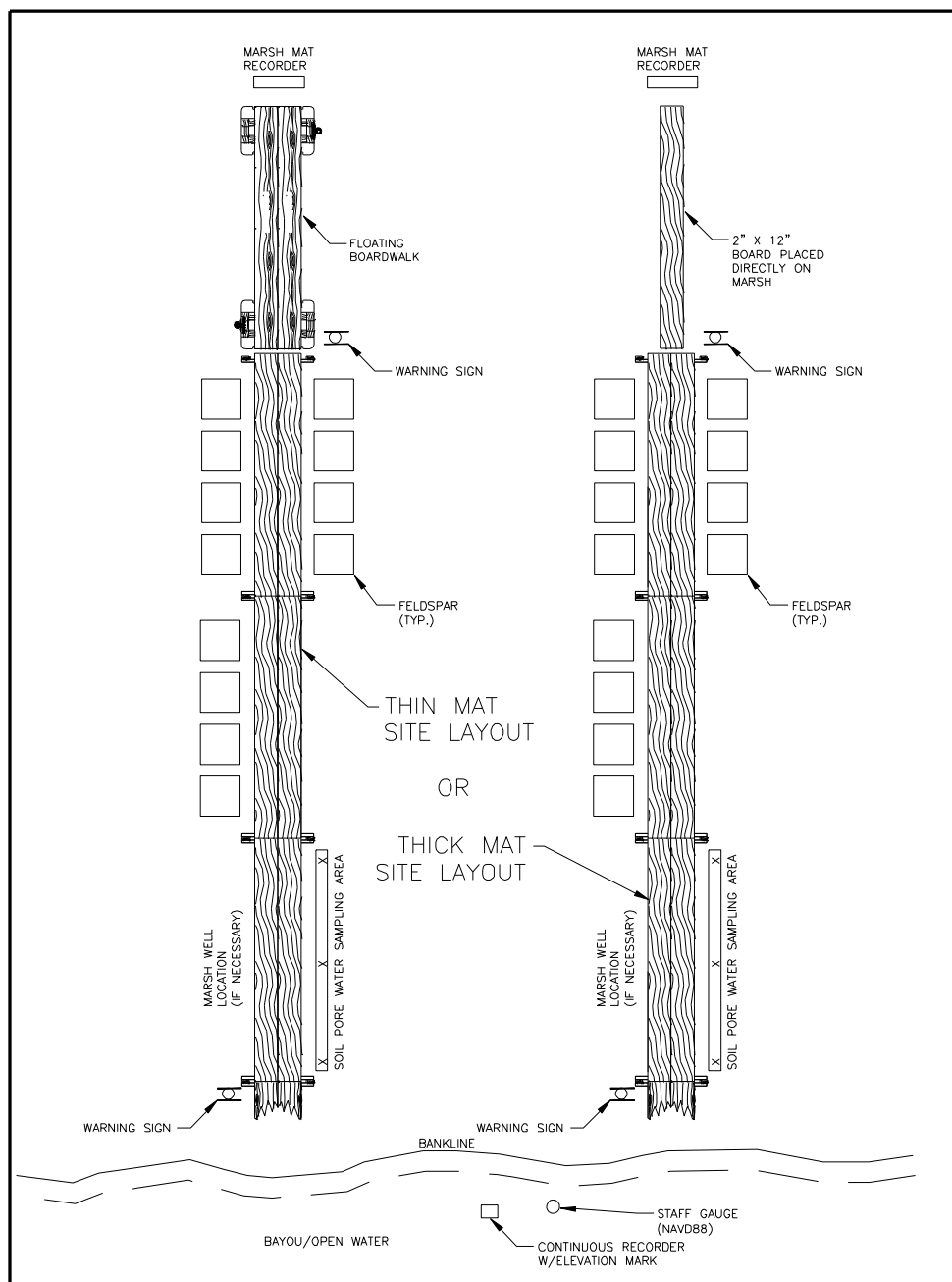
## 2. Site Establishment and Construction



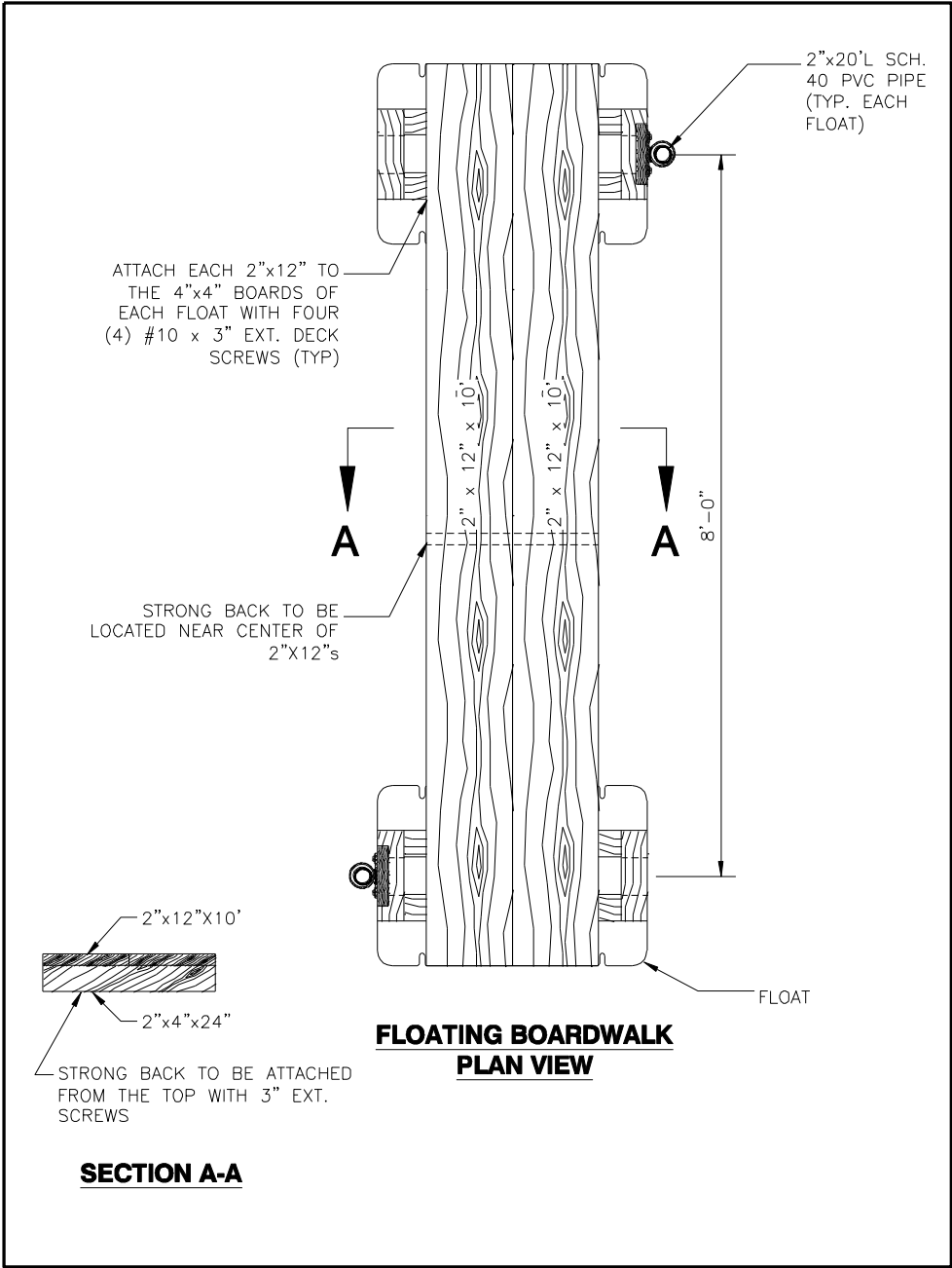
**Figure 2.7.** Typical layout schematic of the constructed site features at an attached marsh site.



## 2. Site Establishment and Construction

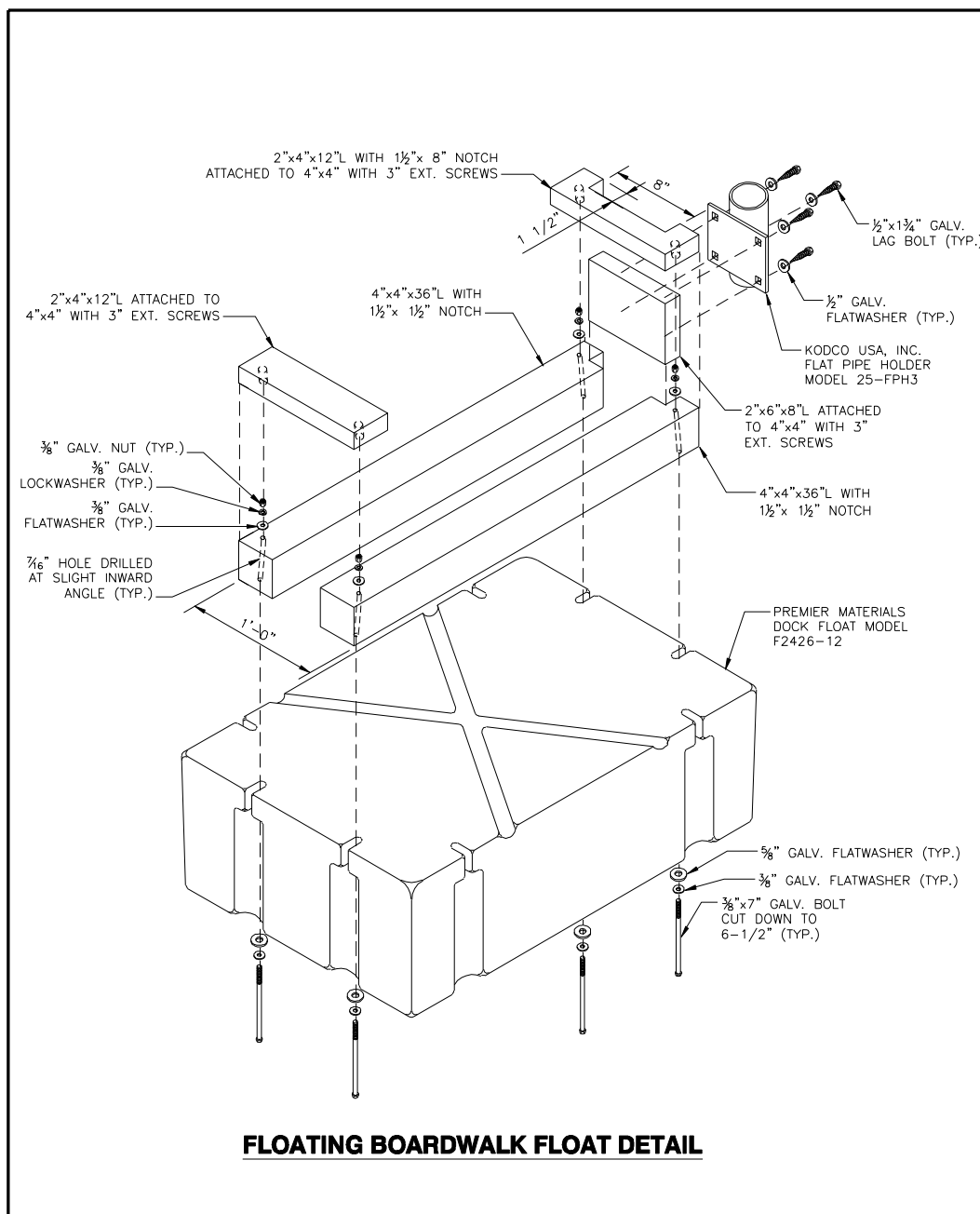


**Figure 2.8.** Typical layout schematic of the constructed site features at a floating marsh site.



**Figure 2.9.** Schematic for the construction of a floating boardwalk.

## 2. Site Establishment and Construction



**Figure 2.10.** Detailed schematic for construction of the float used to support the floating boardwalk.

### 2.2.2 **Deliverables**

The deliverable will be a single PDF of the construction report (Figure 2.11) that should be filled out during the construction of each site. This report will contain information such as the exact coordinates of the boardwalk, specific boardwalk measurements, and other pertinent information regarding the final construction of the boardwalk.

## 2. Site Establishment and Construction

<b>CRMS Site Construction Sheet (Page 1 of 3)</b>																					
Site: _____		Basin: _____																			
Date and Time (CST) of Site Construction: _____		Agency: _____																			
Field Personnel: _____		Weather: _____																			
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><b>1. Sampling Platform Construction:</b></p> <p>Site Coordinates: Access Point _____</p> <p>Center Point (W) _____</p> <p>(X) _____</p> <p>(Y) _____</p> <p>(Z) _____</p> <p>Length of Access Boardwalk (ft): _____</p> <p>Configuration (floating/attached): _____</p> <p>Photos: _____</p> </div> <div style="width: 45%;"> <p>Easting: _____ Northing: _____</p> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <tr> <td style="width: 50%;">X</td> <td style="width: 10%;">RSET</td> <td style="width: 5%;">Y</td> <td style="width: 10%;">Z</td> <td style="width: 10%;">or</td> <td style="width: 5%;">Y</td> <td style="width: 10%;">Z</td> <td style="width: 10%;">RSET</td> <td style="width: 5%;">X</td> </tr> <tr> <td>W</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>W</td> </tr> </table> <p>(if floatant, report W and X only)</p> <p>Boardwalk Bearing: Access <span style="border: 1px solid black; padding: 0 10px;"> </span> Base <span style="border: 1px solid black; padding: 0 10px;"> </span></p> <p>Height top of boards above marsh (ft): _____</p> <p>Total Length of teeth (ft): _____</p> <p>Notes: _____</p> </div> </div>				X	RSET	Y	Z	or	Y	Z	RSET	X	W								W
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Number	Time Stamp	Description																			
		Before Construction																			
		After Construction																			
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><b>2. Warning Signs:</b></p> <p>Total Length 3" PVC (ft): _____</p> <p>Height above Substrate (ft): _____</p> <p>Photos: _____</p> </div> <div style="width: 45%;"> <p>Access Rear</p> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <tr> <td style="width: 50%;">Access Sign (Yellow):</td> <td style="width: 50%;">Rear Sign (Orange):</td> </tr> <tr> <td style="border: 1px solid black; height: 30px;"> </td> <td style="border: 1px solid black; height: 30px;"> </td> </tr> </table> <p>Easting: _____ Northing: _____</p> <p>Notes: _____</p> </div> </div>				Access Sign (Yellow):	Rear Sign (Orange):																
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		Access Before																			
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		Rear After																			
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><b>3. Soil Pore Water Stations</b></p> <p>Coordinates of Location: _____</p> <p>Total Length tooth (ft): _____</p> <p>Height above Substrate (ft): _____</p> <p>Were wells deployed? _____</p> <p>Photos: _____</p> </div> <div style="width: 45%;"> <p>Easting: _____ Northing: _____</p> <p>Station Aa _____</p> <p>Station Bb _____</p> <p>Station Cc _____</p> <p>Bentonite used (cups):</p> <p>10 cm A: _____ B: _____ C: _____</p> <p>30 cm a: _____ b: _____ c: _____</p> <p>Notes: _____</p> </div> </div>																					
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">Number</th> <th style="width: 15%;">Time Stamp</th> <th style="width: 40%;">Description</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td>Before Construction</td> </tr> <tr> <td> </td> <td> </td> <td>After Construction</td> </tr> </tbody> </table>				Number	Time Stamp	Description			Before Construction			After Construction									
Number	Time Stamp	Description																			
		Before Construction																			
		After Construction																			

**Figure 2.11.** Site construction report to be completed during the construction of each site.

## 2. Site Establishment and Construction

<b>CRMS Site Construction Sheet (Page 2 of 3)</b>												
Site: _____		Basin: _____										
Date and Time (CST) of Site Construction: _____		Agency: _____										
Field Personnel: _____		Weather: _____										
<div style="border: 1px solid black; padding: 5px;"> <p><b>4. Staff Gauge</b></p> <div style="display: flex; justify-content: space-between;"> <span>Coordinates of Location: _____</span> <span>Easting: <span style="border: 1px solid black; display: inline-block; width: 100px; height: 20px;"></span></span> <span>Northing: <span style="border: 1px solid black; display: inline-block; width: 100px; height: 20px;"></span></span> </div> <p>Total Length 4x4 (ft): _____</p> <p>Height above Substrate (ft): _____</p> <p>Was gauge attached? _____</p> <p>Photos:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">Number</th> <th style="width: 15%;">Time Stamp</th> <th style="width: 40%;">Description</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td>Before Construction</td> </tr> <tr> <td> </td> <td> </td> <td>After Construction</td> </tr> </tbody> </table> <p>Notes: _____</p> </div>				Number	Time Stamp	Description			Before Construction			After Construction
Number	Time Stamp	Description										
		Before Construction										
		After Construction										
<div style="border: 1px solid black; padding: 5px;"> <p><b>5. Continuous Recorder:</b></p> <div style="display: flex; justify-content: space-between;"> <span>Coordinates of Location: _____</span> <span>Easting: <span style="border: 1px solid black; display: inline-block; width: 100px; height: 20px;"></span></span> <span>Northing: <span style="border: 1px solid black; display: inline-block; width: 100px; height: 20px;"></span></span> </div> <p>Setup: Open water, Well, Mono (circle one)</p> <p>Total Length 4x4, 2x4, or pole (ft): _____</p> <p>Height above Substrate (ft): _____</p> <p>Was recorder deployed? _____</p> <p>Photos:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">Number</th> <th style="width: 15%;">Time Stamp</th> <th style="width: 40%;">Description</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td>Before Construction</td> </tr> <tr> <td> </td> <td> </td> <td>After Construction</td> </tr> </tbody> </table> <p>Notes: _____</p> </div>				Number	Time Stamp	Description			Before Construction			After Construction
Number	Time Stamp	Description										
		Before Construction										
		After Construction										
<div style="border: 1px solid black; padding: 5px;"> <p><b>6. Marsh Mat Recorder:</b></p> <div style="display: flex; justify-content: space-between;"> <span>Coordinates of Location: _____</span> <span>Easting: <span style="border: 1px solid black; display: inline-block; width: 100px; height: 20px;"></span></span> <span>Northing: <span style="border: 1px solid black; display: inline-block; width: 100px; height: 20px;"></span></span> </div> <p>Set-up: Floating or Static (circle one)</p> <p>Recorder Length/Distance Information:</p> <div style="display: flex;"> <div style="flex: 1;"> <p>a. Total length of 2" PVC (ft): _____</p> <p>b. Length of 2" PVC below the marsh (ft): _____</p> <p>c. Total length of aluminum pipe installed (ft): _____</p> <p>d. Top of aluminum pipe to elevation mark (1/4" hole) (ft): _____</p> <p>e. Firm substrate to top of pipe (ft): _____</p> </div> <div style="flex: 1;"> <p>Marsh Measurement Information:</p> <p>a. Mat thickness (ft): _____</p> <p>b. Firm substrate to mat surface (ft): _____</p> <p>c. Fluid ooze layer thickness (ft): _____</p> </div> </div> <p>Photos:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">Number</th> <th style="width: 15%;">Time Stamp</th> <th style="width: 40%;">Description</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td>Before Construction</td> </tr> <tr> <td> </td> <td> </td> <td>After Construction</td> </tr> </tbody> </table> <p>Notes: _____</p> </div>				Number	Time Stamp	Description			Before Construction			After Construction
Number	Time Stamp	Description										
		Before Construction										
		After Construction										
<div style="border: 1px solid black; padding: 5px;"> <p><b>7. Potential Site Problems:</b> (Is site constructed exactly as described in site visit report? Were future sites damaged?)</p> <p>_____</p> <p>_____</p> </div>												

**Figure 2.11 (cont.).** Site construction report to be completed during the construction of each site.

## 2. Site Establishment and Construction

**CRMS Site Construction Sheet (Page 3 of 3)**

CRMS Site: \_\_\_\_\_ Center Coordinates: Easting \_\_\_\_\_  
 Date & Time: \_\_\_\_\_ Northing \_\_\_\_\_  
 Personnel: \_\_\_\_\_

**N**

200 m

200 m

**S**

Site Description: (Location and orientation of access route, boardwalk, SET, continuous recorder, and vegetation transect)

Checklist	Notes:	LEGEND
<input type="checkbox"/> Compass		<input type="checkbox"/> Access Point
<input type="checkbox"/> Camera		<input type="checkbox"/> Center Point
<input type="checkbox"/> GPS		<input type="checkbox"/> Marsh Well
<input type="checkbox"/> Survey Rod		<input type="checkbox"/> RSET
<input type="checkbox"/> Permanent Marker		<input type="checkbox"/> Continuous Recorder
		<input type="checkbox"/> Vegetation Transect
		<input type="checkbox"/> Access Route
		<b>AB</b> – Access Boardwalk
		<b>BB</b> – Base Boardwalk

**Figure 2.11 (cont.).** Site construction report to be completed during the construction of each site.

### 3. HYDROLOGIC DATA

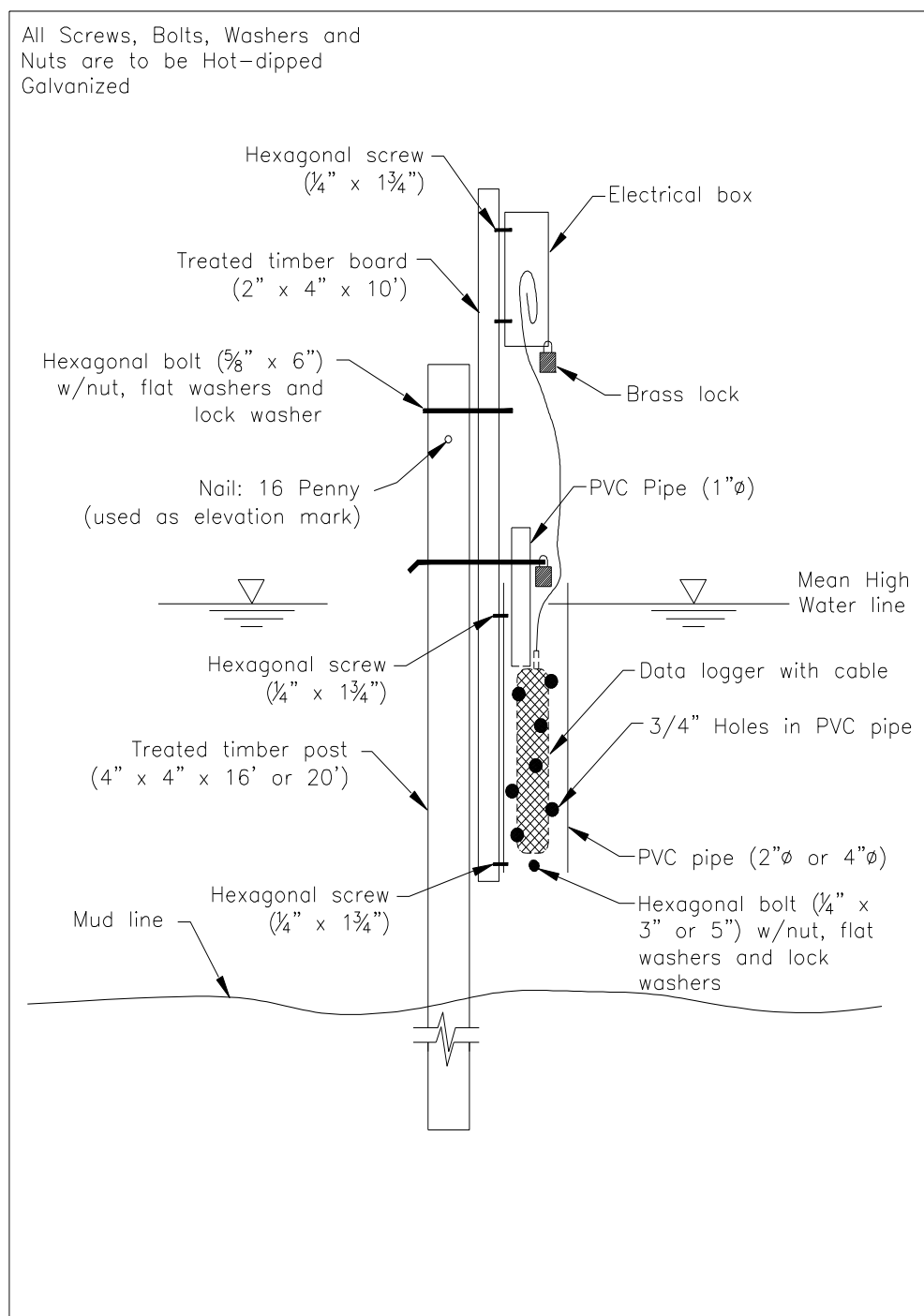
Highly variable water levels and saltwater intrusion have been shown to cause adverse effects on the health of coastal wetland ecosystems (Gagliano et al. 1981). Consequently, many wetland restoration projects have specific goals to reduce variability in water level and decrease average salinity values. The CPRA collects hydrologic data on a continuous and/or discrete basis to determine if project goals are being met or to determine baseline conditions. Continuous water level, temperature, specific conductivity, and salinity data are collected hourly from surface waters at permanent monitoring stations with continuous recording instruments (Steyer et al. 1995). Discrete data are collected during periodic (e.g., monthly) field trips during which salinity, specific conductance, and temperature are measured at multiple locations with a hand-held salinity meter. Discrete measurements are taken in surface water or in soil porewater extracted with a sipper probe.

#### 3.1 Continuous Data Collection

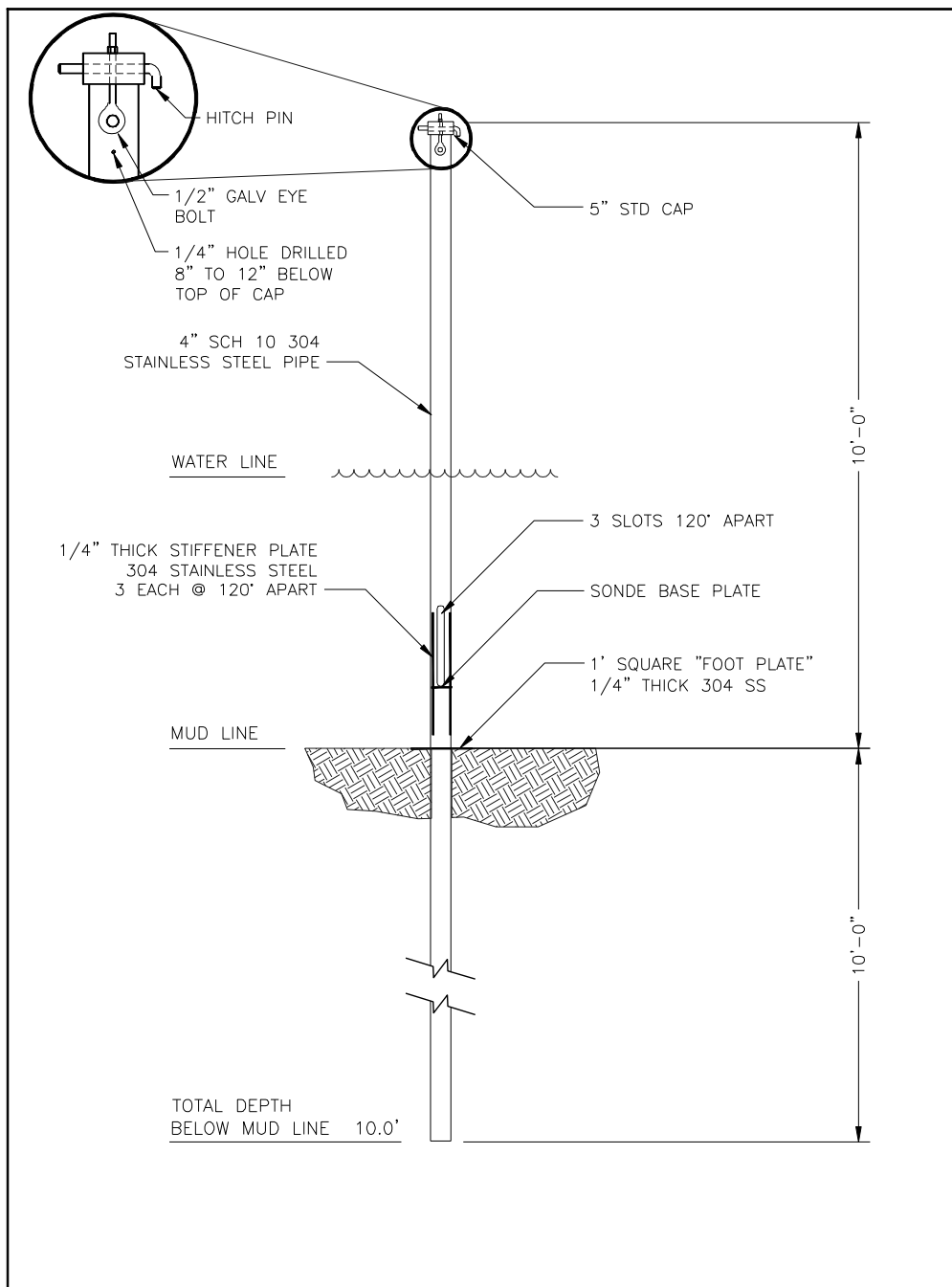
With the large diversity of ecosystems in the coastal zone, various sampling station designs are used to continuously measure water level and salinity. These station designs were developed for the following three environments:

1. *Open water habitats with sufficient yearly water levels to continually submerge the continuous recorder data sensor:*
  - a. The **wooden post system** consists of a 4" x 4" x 20-ft treated wooden post driven into the substrate of an open water body to refusal (Figure 3.1). [Note: Refusal occurs when the post no longer penetrates the substrate after several attempts to drive it further with a pile driver.] A perforated PVC pipe and electrical box are mounted onto a 2" x 4" x 10-ft board, which is attached onto the wooden post via a bolt and hitch pin. This method works well in meandering bayous, canals, and interior marsh channels where water depth is less than 8 ft, and where wave energy and water velocity are low to moderate.
  - b. The **mono-pole system** is a stainless steel pipe that has a quarter-inch plate welded at a depth such that the plate rests on the bottom for stabilization (Figure 3.2). The pipe has numerous slits in the water column portion of pipe to allow water exchange. While this method can be used for all environments, it is most feasible for use in high-velocity or high-energy areas such as rivers and large navigational waterways.





**Figure 3.1.** Typical wooden post station.



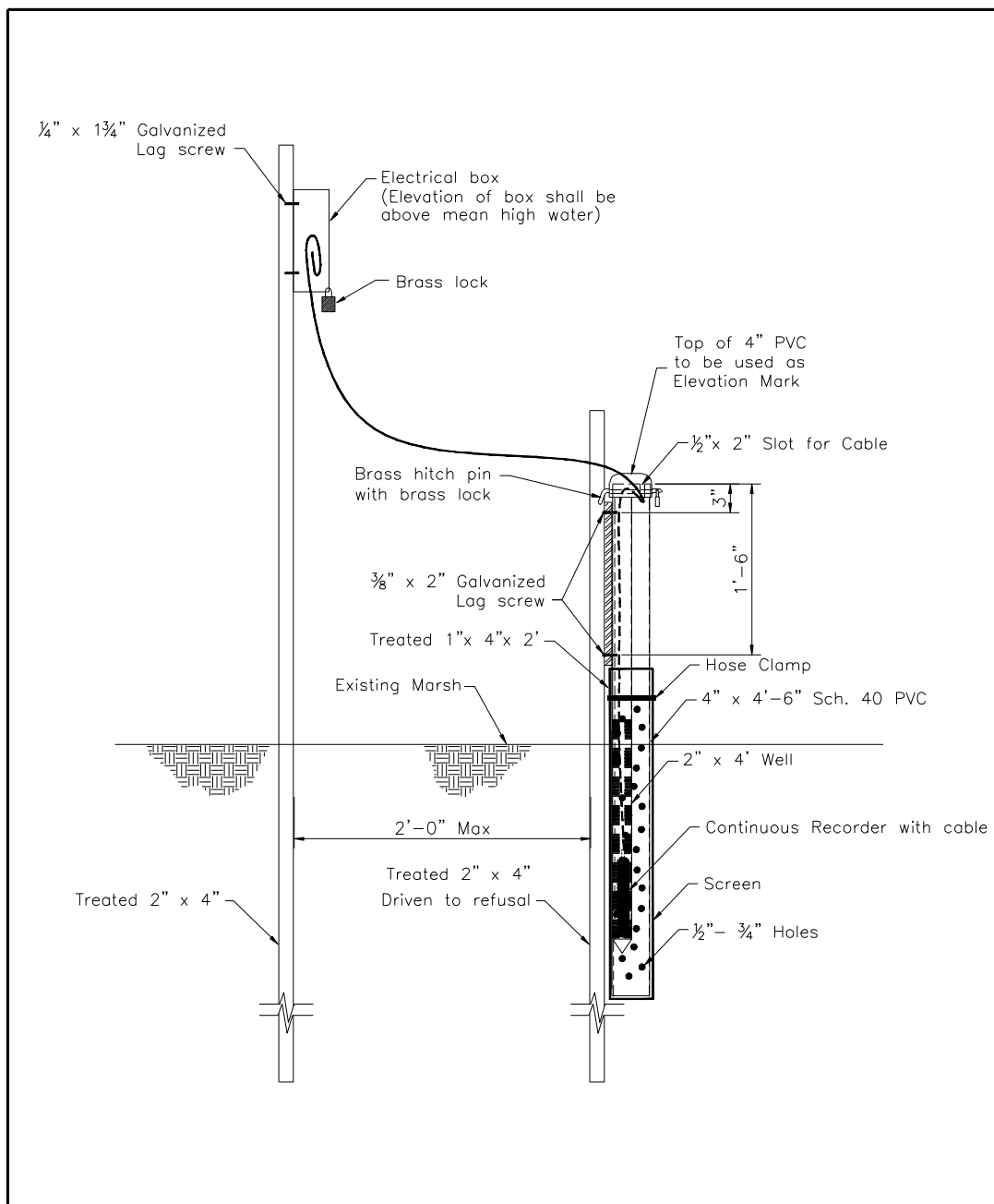
**Figure 3.2.** Typical stainless steel mono-pole station.

2. *Marsh or swamp habitats where flooding is ephemeral, not deep enough to continually submerge the continuous recorder, or where there is no open water in which to place a continuous recorder:*

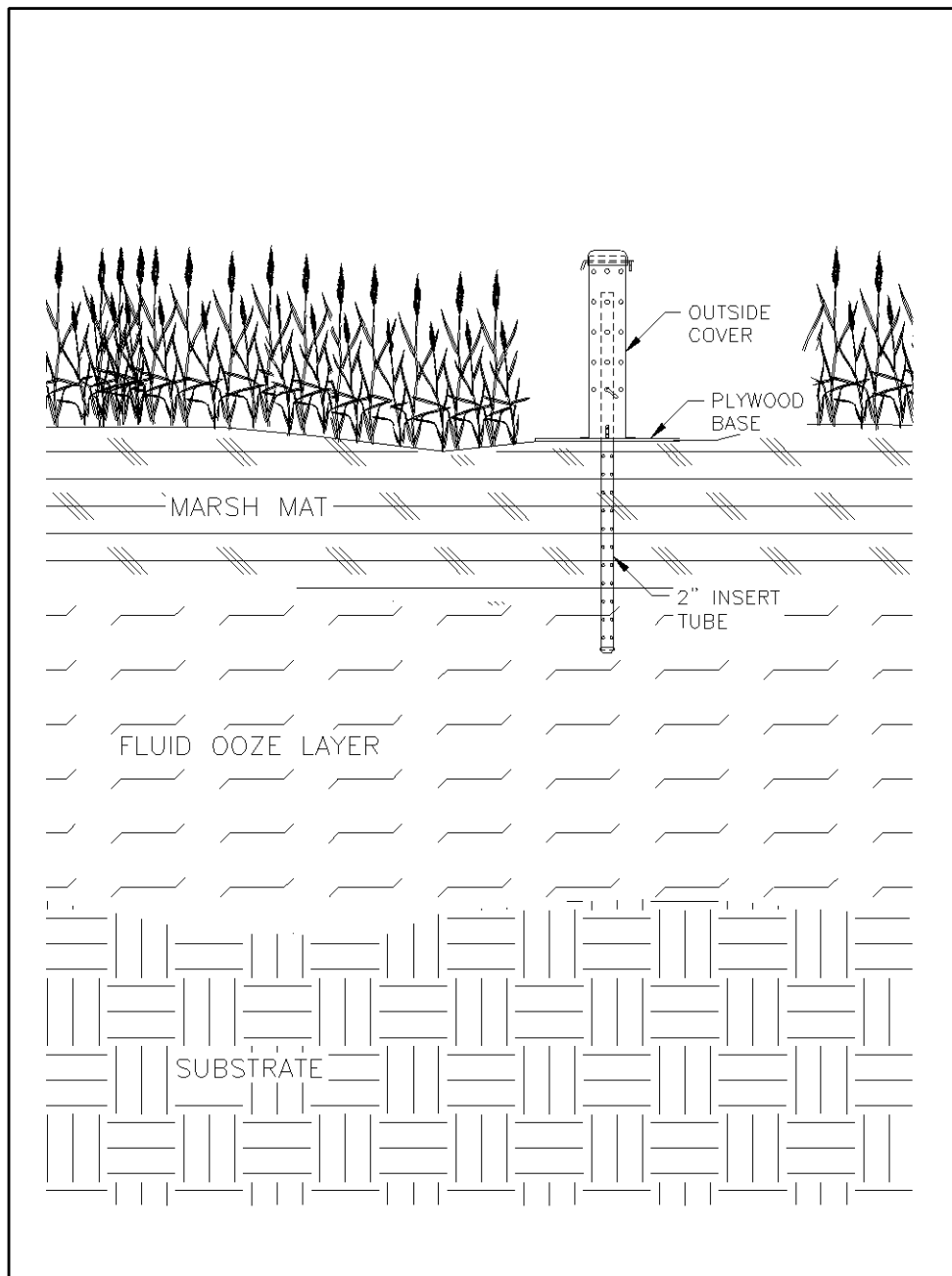
The **well system** is a PVC well (Figure 3.3) with screens that allow surface water to enter and exit the well when the marsh surface is flooded.

When the water table drops below the marsh surface, the well screens allow soil porewater to enter and exit the well. Because the CPRA's interest is mainly surface water properties, how these wells function must be considered when processing (i.e., QA/QC) and interpreting the data. For example, when comparing surface water from wells to surface water at open water stations, salinity recorded during periods when the water level is below the marsh surface will not be comparable.

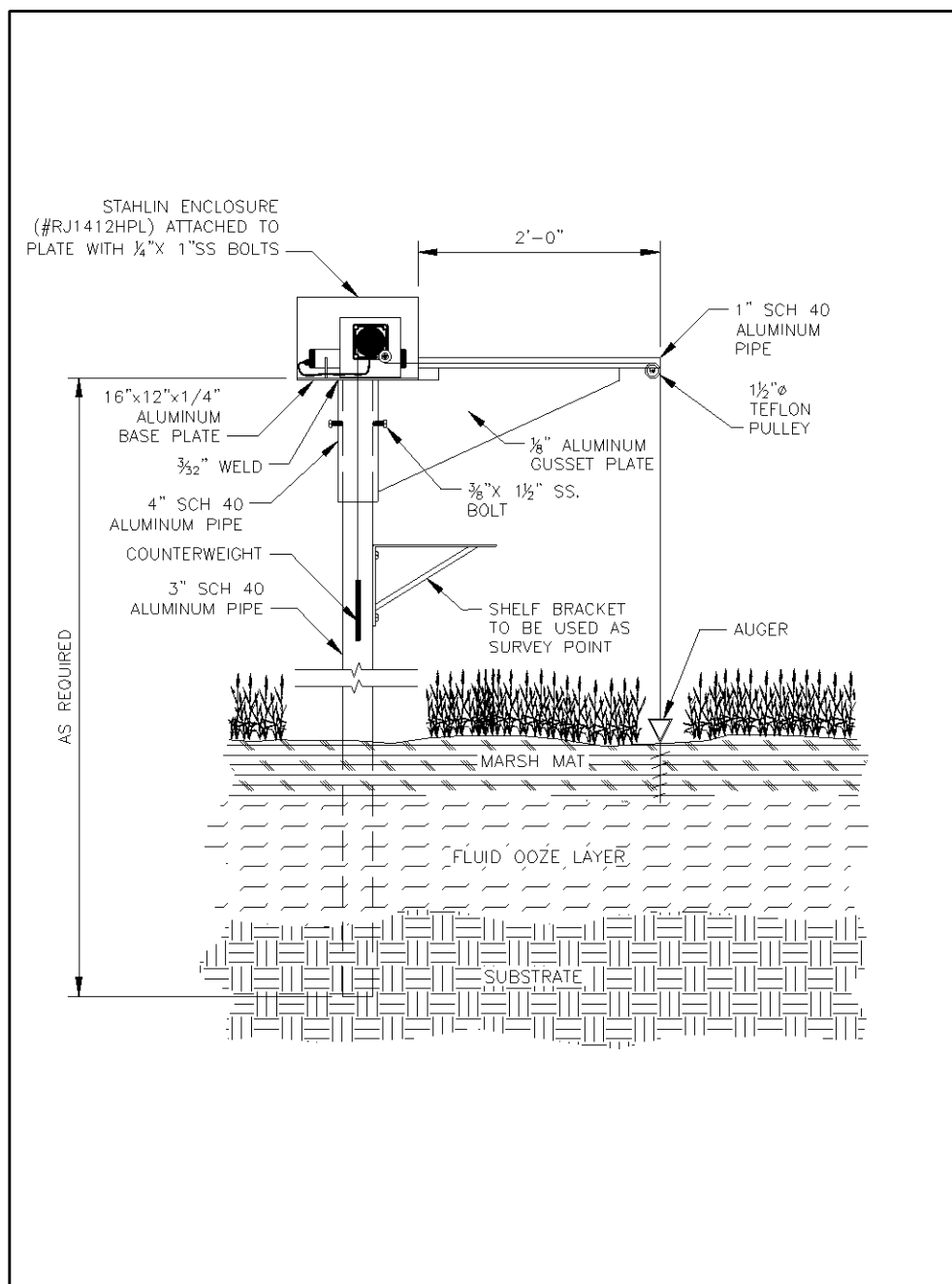
3. *Floating marshes where the marsh surface is detached and able to float vertically as water level fluctuates:*
  - a. The **floating system** is appropriate for marshes with relatively thick buoyant mats (e.g., >12 in.) capable of supporting the weight of the system without influencing the mat's ability to move vertically. This system preferably suspends a continuous recorder below the marsh mat in the fluid ooze layer (Figure 3.4), but it may suspend the continuous recorder within the marsh mat. Because this system is attached to the floating mat and the distance from the water level sensor to the marsh surface is known, water level in relation to the marsh surface can be calculated. Data from a surveyed reference continuous recorder station in an adjacent channel are then used to convert the marsh mat surface elevation and water level to a vertical datum.
  - b. In areas where the marsh mat is thin and will not support the floating system, the **static system** will be utilized. This system allows the mat to move vertically, while a post containing a surveyed mark for elevation reference is embedded through the mat and into the underlying substrate. The post supports a counterweight and pulley system that is attached to the marsh surface with a spiral auger (Figure 3.5). As the marsh surface moves vertically, the cable rotates around the pulley system, which is attached to a digital shaft encoder. This rotation is converted to a digital signal that is recorded by the data logger (OTT-Thalimedes or equivalent). This recorder only measures the movement of the marsh mat.



**Figure 3.3.** Typical marsh well station.



**Figure 3.4.** Typical floating marsh mat continuous recorder station.



**Figure 3.5.** Typical static marsh mat continuous recorder station.

### 3.1.1 Instrumentation

The CPRA currently utilizes the YSI 600LS, Hydrolab MS5, or equivalent continuous recorder with a vented cable, as the basic model that measures and stores water temperature (°C), specific conductance (µS/cm), salinity (ppt), and water level (m or ft) data at specified time intervals. The water level sensor must be a vented sensor that has a range of 0 to 9.1 m (30 ft), a minimum accuracy of ±0.003 m (0.01 ft) in depths to 3.0 m (10 ft), and a minimum accuracy of ±0.018 m (0.06 ft) in depths of 3.0 to 9.14 m (10 to 30 ft).

The water temperature and specific conductivity sensor must meet or exceed the following standards. The temperature sensor must be able to function in a range of -5 to 45 °C, have a range of ±0.15 °C and a resolution of 0.01 °C, and be able to work in depths of 200 m (656 ft). The conductivity sensor must be able to function in a range of 0 to 100 mS/cm, have an accuracy of ± 0.5% of readings and a resolution of 0.001 mS/cm to 0.1 mS/cm, and be able to function in 200 m (656 ft) of water. The salinity values are calculated from the conductivity and water temperature readings and must have a range of 0 to 70 ppt, an accuracy of ± 1.0% of readings or 0.1 ppt (whichever is greater), and a resolution of 0.01 ppt. In addition to the specifications above, the instrument shall be capable of exporting the raw data through a field display unit or field computer as a .txt file to be processed and imported into the CPRA main database.

To verify that the continuous recorder is within calibration at the time of deployment and to calculate the drift of the continuous recorder due to biofouling, a portable, hand-held discrete instrument (YSI 30 or equivalent) is used. This water quality instrument provides the user with water temperature (°C), specific conductance (µS/cm), and salinity (ppt) measurements. The YSI 30 or equivalent must be capable of taking salinity readings in water depths up to 7.6 m (25 ft). The YSI 30 or equivalent must be capable of undergoing field calibration by using push buttons; also, it must have a backlit display, automatically compensate for temperature, and use a four-electrode conductivity cell. Minimum accuracy requirements for the instrument are found in Table 3.1. Any instrumentation that does not meet these specifications must be approved by the CPRA.

**Table 3.1.** Conductivity, salinity, and temperature range and accuracy minimum standards for the hand-held water quality units.

Measurement	Range	Resolution	Accuracy
Conductivity	0 to 499.9 $\mu\text{S/cm}$	0.1 $\mu\text{S/cm}$	$\pm 0.5\%$ full scale
	0 to 4999 $\mu\text{S/cm}$	1 $\mu\text{S/cm}$	$\pm 0.5\%$ full scale
	0 to 49.99 $\text{mS/cm}$	0.01 $\text{mS/cm}$	$\pm 0.5\%$ full scale
	0 to 200.0 $\text{mS/cm}$	0.1 $\text{mS/cm}$	$\pm 0.5\%$ full scale
Salinity	0 to 80 ppt	0.1 ppt	$\pm 2\%$ or $\pm 0.1$ ppt
Temperature	-5 to $+95^{\circ}\text{C}$	0.1 $^{\circ}\text{C}$	$\pm 0.1^{\circ}\text{C}$

A float-operated shaft encoder with data logger (OTT-Thalimedes or equivalent) is used to continuously measure the vertical movement of floating marsh mats in the static system (Figure 3.5). As the mat moves vertically, the changes are transferred to a pulley on the encoder unit using a cable-counterweight system. As the pulley rotates, an electrical signal is transferred via a cable to the data logger where it is stored. The data logger must be able to store data in specified intervals (primarily hourly). The data logger must be able to store the data (in feet) with its associated date and time. The data logger must be able to store a minimum of 9,000 readings and transfer the data to a laptop computer or other electronic device via cable, and it must be able to fit into a small electrical box when deployed in the field.

### 3.1.2 Station Construction and Surveying

To ensure proper and consistent data collection, the following construction procedures and specifications have been developed by the CPRA. The construction of all continuous recorder or staff gauge stations associated with CRMS sites requires the use of the “CRMS Site Construction Sheet” (Figure 2.11). The appropriate sections of this sheet shall be filled out once station construction is completed.

#### 3.1.2.1 *Open Water*

When a station requires establishment in an open water environment, the two set-ups that are recommended are the wooden post for low-energy environments and the mono-pole for high-energy environments. However, a hybrid design may be used in high-energy environments with the approval of the CPRA (see note at the end of the Mono-pole section, which follows). Below is a materials list for construction of a single station, as well as the recommended procedures for construction and surveying.



► **Wooden post system:**

*Materials:*

1. 1 - 4" x 4" x 16-ft or 20-ft treated post
2. 1 - 2" x 4" x 10-ft treated board
3. 4 - Reflectors (one per side of post) with screws for attachment
4. 1 -  $\frac{5}{8}$ " x 6" hot-dipped galvanized hexagonal bolt with two flat washers, one locking washer, and one nut
5. 4 -  $\frac{1}{4}$ " x 1  $\frac{3}{4}$ " hot-dipped galvanized wood screw
6. 1 -  $\frac{1}{4}$ " x 3" or 5" hot-dipped galvanized hexagonal bolt with two flat washers, one locking washer, and one locking nut; bolt length is dependent on PVC diameter, which is determined by instrument type
7. 2 - Brass locks provided by the CPRA
8. 1 - 2" or 4" schedule 40 PVC perforated pipe with multiple  $\frac{3}{4}$ " holes (28"–36" in length or a minimum of 12" longer than the anticipated instrument); diameter of pipe is dependent on the diameter of the continuous recorder
9. 1 - 1" schedule 40 PVC pipe (approximately 24"–36" in length)
10. 1 -  $\frac{5}{8}$ " x 9" stainless steel hitch pin
11. 1 - 16 or 20 penny galvanized common nail
12. Electrical box (NEMA 3R-Rainproof or similar) that can be secured with a padlock and can house the cable end and desiccant tube from direct exposure to weather

Tools:

1. Pile driver (a.k.a., widow maker) used for driving posts into the ground: a cylindrical steel device that is approximately 36" in length, has an inside diameter  $\geq 5 \frac{1}{2}$ " and weighs approximately 60 pounds (or similar device)
2. Wrenches
3. Cordless skill saw and/or reciprocating saw
4. Cordless drill and bits (various sizes)
5. Hammer
6. Socket set with driver
7. Level
8. Duct tape
9. Measuring device (a surveyor's rod capable of measuring in feet, tenths, and hundredths)
10. Personal protective equipment (minimum of gloves and eye protection)
11. Digital camera

Construction and Installation:

*Continuous Recorder (CR) support assembly (can be constructed in the office):*

1. Mount the electrical box to one end of the 2" x 4" x 10-ft treated board with 2 - 1/4" x 1 3/4" screws.
2. On the other end of the board, mount the 2" or 4" PVC pipe using 2 - 1/4" x 1 3/4" screws (one at each end of the PVC pipe). Note: A hole may need to be drilled for access.
3. At the bottom end of the PVC, near the end of the board, drill a 1/4" hole 90° from the screw through both sides of the PVC.
4. Thread the 1/4" x 3" or 5" bolt and secure with washers and nut. This serves as the resting place for the instrument. Notes: (1) Only tighten the nut to the PVC pipe; do not overtighten, causing the PVC to bend. (2) The use of PVC caps is not specified for this application due to the increase of biofouling that could occur.

*Support post installation:*

1. Determine the correct location for the station according to the approved PSV packet (Figure 2.2) or as directed by the CPRA, and shoot a "before construction" picture.
2. Cut a point at one end of the wooden post to facilitate installation (point may be cut prior to going to the site).
3. Place the timber post in the water with the point down. Slowly lower the post into the water to penetrate the subsurface.
4. Using a level, make sure the post remains plumb in all directions as the post is being installed.
5. Once the post no longer penetrates the substrate by the post's own weight, then the pile driver can be placed on the top of the post.
6. Using the pile driver, drive the post into the substrate until resistance is met. Note: Refusal occurs when the post no longer penetrates the substrate after several attempts with the pile driver. Approximately 4 ft of the post shall remain above the mean high water level or the marsh surface.
7. Make sure that the post is plumb in all directions.
8. If the top of the post was damaged, cut the damaged section off. Make sure to cut the post square.

*Mounting the CR support assembly to the wooden post:*

1. With the CR support assembly in hand, determine a vertical position in the water column so that 1) the continuous recorder sensor is submerged during low water events, 2) the electrical box is above mean high water, and 3) the end of the

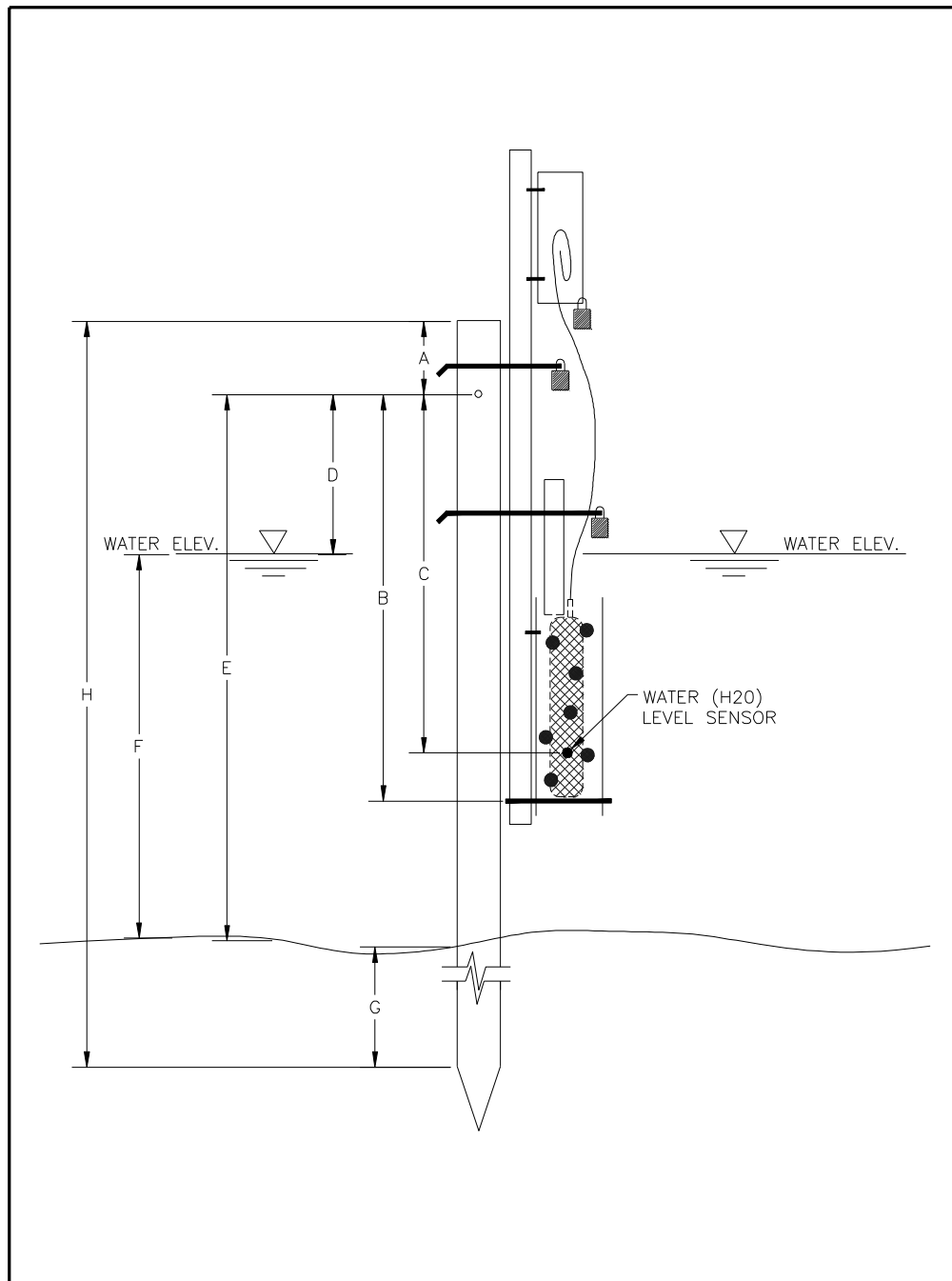
continuous recorder is a minimum of 4" above the mud line. In shallow water this is easy to achieve, but in deeper water, all three criteria cannot be met. In this case, position the CR support assembly so that criteria 1 and 2 are met, and disregard the criterion that the continuous recorder be 4" above the mud line (i.e., criterion 3).

2. Secure the 2" x 4" CR support assembly to the wooden post in two or three places with duct tape.
3. Drill a  $\frac{3}{4}$ " hole a minimum of 6" from the top of the post through the post and the 2" x 4" board.
4. Secure with the 6" bolt, washers, and nut.
5. Drill a  $\frac{3}{4}$ " hole a minimum of 16" from the hole in step 2 such that the hitch pin is above normal water levels but close to the PVC used to house the instruments.
6. Place the continuous recorder inside the PVC housing pipe in order to measure the length of the 1" PVC used to secure the instrument (stop-pipe) and prevent vertical movement.
7. Measure from the top of the instrument to the top of the bottom  $\frac{3}{4}$ " hole, and then add a minimum of 4".
8. Cut the 1" PVC to the measurement in step 7.
9. Place 1" PVC on top of the instrument to determine where to drill the hole that will allow the hitch pin to go through the post, board, and 1" PVC pipe.
10. Drill a hole in the 1" PVC for the  $\frac{5}{8}$ " hitch pin.
11. Drive a 16 penny nail two-thirds of the way into the side of the post. This nail must be driven perpendicular to the post in order to serve as a reference mark for measuring water level while servicing. Notes: (1) No post shall have more than one nail. (2) The nail should be positioned on either side of the 2" x 4" board and on the side least likely to be damaged by the boat during servicing.
12. Secure three reflectors near the top of the wooden post and the remaining reflector to the 2" x 4" board.
13. Once completed, the station shall resemble Figure 3.1.
14. Document the measurements on the "Continuous Recorder Water Level Sensor Data Sheet" (Figure 3.6) by referencing Figure 3.7.
15. Shoot an "after construction" photo.
16. Complete the *Continuous Recorder* section (#5) on the "CRMS Site Construction Sheet" (Figure 2.11), including the station coordinates, the total length of the support post (ft), the height of the station above the substrate (ft), and number/time stamp of photos. Document whether a continuous recorder was deployed and provide notes regarding station construction, if necessary.

### 3. Hydrologic Data

CONTINUOUS RECORDER WATER LEVEL SENSOR DATA SHEET			
Station: _____			
Date of Measure: _____		Time (CST): _____ Agency: _____	
Reason for Measure:      Post / Pole Installed                      Periodic Check                      Change of Instrumentation			
Field Personnel: _____			
Continuous Recorder: _____ (Manufacturer)		_____ (Model) _____ (Serial Number)	
(Deployed) _____ (Overall length)		_____ (Top to water level sensor)	
Date of Post / Pole Installation: _____			
<input type="checkbox"/> <u>Wooden Post</u>		<input type="checkbox"/> <u>Mono-Pole</u>	
_____ (ft) A. Nail to top of post		_____ (ft) A. Top of 1/4" hole to top of pipe	
_____ (ft) B. Nail to bottom of continuous recorder		_____ (ft) B. Top of 1/4" hole to bottom of continuous recorder	
_____ (ft) C. Nail to water level sensor		_____ (ft) C. Top of 1/4" hole to water level sensor	
_____ (ft) D. Nail to water line		_____ (ft) D. Top of 1/4" hole to water line	
_____ (ft) E. Nail to subsurface		_____ (ft) E. Top of 1/4" hole to subsurface	
_____ (ft) F. Water depth		_____ (ft) F. Water depth	
_____ (ft) G. Penetration depth		_____ (ft) G. Penetration depth	
_____ (ft) H. Total pole length		_____ (ft) H. Total pole length	
		_____ (ft) I. Mud line to load plate (if not resting on subsurface)	
		_____ (ft) J. Amount of casing removed (if damage was done during installation)	

**Figure 3.6.** Continuous recorder water level sensor data sheet.



**Figure 3.7.** Schematic of distances needed to be measured for elevation calculations for the wooden post continuous recorder set-up.

► ***Mono-pole system:***

The mono-pole is fabricated from a metal pole and thus is more durable than the wooden post design. Figure 3.2 illustrates the design specifications. Installation of the mono-pole is best accomplished with a vibra-core. A pile driver badly damages the end of the mono-pole and should not be used. Note: A hybrid design with features of the wooden post and mono-pole design can be used if needed at relatively deep and high-energy sites. This alternate design has a 3" x 20-ft schedule 40 aluminum post as the support post, and the CR support assembly is attached to the aluminum post in a similar manner as in the wooden post design.

**Snorkel:** A subset of CRMS stations had a 'snorkel' mounted to the 4x4 sonde post. The snorkel effectively allows the sonde cable to be raised above potential high water levels (storm surge, spring floods). The snorkel consists of a cable housing constructed from PCS pipe mounted to a 2x4 that extends above the sonde setup.

### **3.1.2.2 Marsh Well**

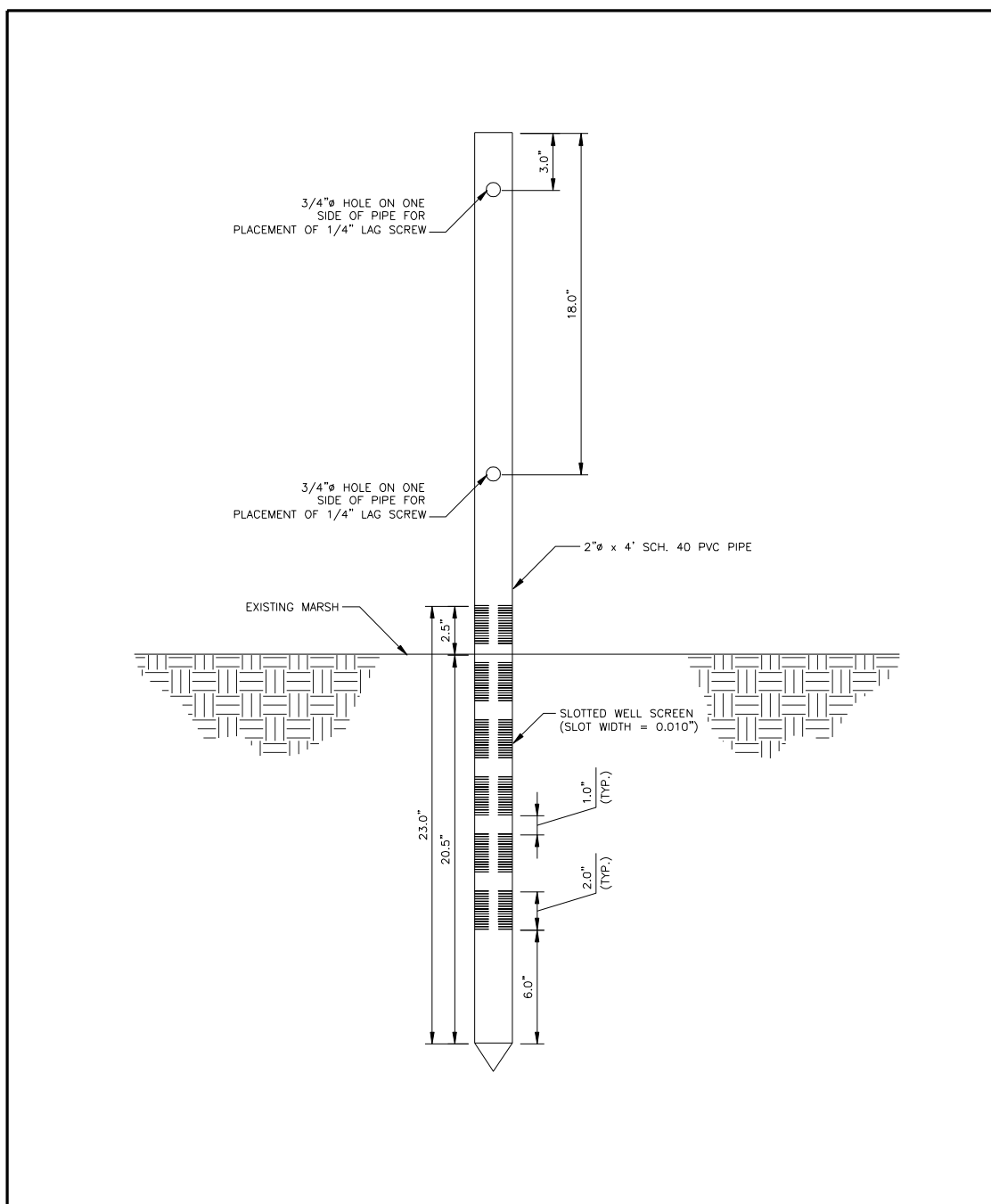
The marsh well method will be utilized at sites where there are no adequate water bodies to constantly submerge a continuous recorder during low-water events, or where the site may be entirely marsh or swamp (see CRMS-*Wetlands* Site Decision Tree, Figure 2.5). The marsh well station will be established adjacent to the boardwalk in a predetermined location (Figures 2.7 and 2.8).

*Materials:*

1. 2 - 2" x 4" x 8-ft or 10-ft treated boards
2. 4 - 1/4" x 1 3/4" hot-dipped galvanized lag screws
3. 1 - Electrical box
4. 1 - 2" x 4-ft schedule 40 PVC slotted well (slot width = 0.01") (Figure 3.8)
5. 1 - 1" schedule 40 PVC with a 6" brass hitch pin
6. 1 - 16 penny hot-dipped galvanized nails
7. 2 - CPRA-issued brass locks
8. 1 - 4" (4–6-ft) schedule 40 PVC with cap
9. 1 - mesh screen (PVC, aluminum, or copper); resistant to saltwater
- 10.2 - hose clamps (large enough to secure screen to 4" PVC)
- 11.1 - 1" x 4" x 2-ft treated board for spacer
- 12.1 - 4" schedule 40 PVC cap
- 13.2 - 1 1/2" galvanized screws

Tools:

1. Pile driver: a cylindrical steel device that is approximately 36" in length, has an inside diameter  $\geq 5 \frac{1}{2}$ " and weighs approximately 60 pounds; used for driving post or equivalent device used to drive the post to resistance.
2. Wrenches
3. Cordless skill saw and/or reciprocating saw
4. Cordless drill and bits (various sizes)
5. Hammer
6. Socket set with driver
7. Measuring device (a surveyor's rod capable of measuring in feet, tenths, and hundredths)
8. 4" diameter soil core extractor (~3 ft long)
9. Personal protective equipment (e.g., gloves and eye protection)
10. Digital camera



**Figure 3.8.** Detailed drawing of the inner 2" PVC well where the continuous recorder will be placed in the marsh well set-up.



Construction and Installation:

- a. From the boardwalk, determine the correct location for the marsh well according to the approved PSV packet (Figure 2.2) or as directed by the CPRA, and shoot a “before construction” picture.
- b. Drive a 2” x 4” x 8-ft or longer board to resistance using a pile driver, making sure the board remains plumb. This post will serve as the well support post and as a benchmark for the well (i.e., it will be surveyed to a known datum). Therefore, an adequate length of board must remain above the marsh surface to allow full attachment of the well, but the post should not extend too high, as to allow lateral movement.
- c. Extract a 24”-deep pilot hole adjacent to the well support post using a 4”-diameter soil core to minimize clogging of the marsh well’s screens during installation.
- d. Remove the soil and place in bucket.
- e. Drill ½” to ¾” holes along the length of the 4” PVC that will be below the marsh and extending to 2” above the marsh (Figure 3.3). Cover the sides and bottom of the vented portion of the 4” well with the mesh screen and secure with hose clamps. Place the 4” PVC marsh well with screen into the pilot hole. The top 2” section of screen shall remain above the marsh surface as illustrated in Figure 3.8.
- f. Secure the 4” PVC well to the board using two (2), ¼” x 1 ¾” lag screws approximately 3” and 18” from the top. Note: A ¾” hole will have to be drilled on one side to facilitate access for securing the screw. See Figures 3.3 and 3.8.
- g. Place the 2” PVC well inside the 4” pipe and secure with 2, 1 ½” screws.
- h. Place the instrument into the 2” PVC well. Then place the 1” PVC pipe in the well to secure the instrument.
- i. Drill a hole through the board and the 4” PVC pipe above the 2” PVC well to receive the hitch pin.
- j. Cut the 1” PVC pipe approximately 4” above the hole (beneath the top of the 4” PVC well) to remove any excess pipe.
- k. Secure the cap onto the 4” PVC well.
- l. Drive a nail into the side of the support post leaving ~ 2” to serve as the survey mark.
- m. From the boardwalk, drive a second 2” x 4” board into the soil a maximum of 2 ft from the well station. This board does not have to be driven to resistance. It only has to be stable enough to house the electrical box and cable, but it must be high enough to not allow water to enter the box during high-water events.
- n. Mount the electrical box to the board using the ¼” x 1 ¾” lag screws. The box should be a minimum of 4 ft above the surface.
- o. Upon completion of construction the station shall resemble Figure 3.3.
- p. Document the measurements on the “Continuous Recorder Water Level Sensor Data Sheet” (Figure 3.6). Note: Because the data sheet is not specifically designed for a well system, use the wooden post column, noting that it is a well station.
- q. To document proper installation, shoot an “after construction” photograph.

- r. Complete the *Continuous Recorder* section (#5) on the “CRMS Site Construction Sheet” (Figure 2.11), including the station coordinates, the total length of the support post (ft), the height of the station above the substrate (ft), and number/time stamp of photos. Document whether a continuous recorder was deployed and provide notes regarding station construction, if necessary.

### 3.1.2.3 *Floating Marsh*

Due to the varying degrees of mat thickness among floating marsh sites, two measuring systems have been developed and utilized by the CPRA to measure mat vertical movement. The floating system will be utilized in areas that have thicker mats that will be able to support the weight of the system without affecting the vertical movement of the mat. The static system will be used in areas where the mat is too thin to utilize the floating system.

#### ► *Floating system:*

The floating system utilizes a piece of plywood and a series of PVC pipes that are secured to the surface of the marsh by four spiral anchors. Within these PVC pipes, a continuous recorder is deployed to record the water temperature, specific conductance, salinity, and water level on an hourly basis, unless otherwise specified by the CPRA. The following procedures are used to construct the housing for the continuous recorder.

#### *Materials:*

1. Schedule 40, 6" PVC pipe
2. Schedule 40, 6" PVC cap
3. Schedule 40, 2" PVC pipe
4. Schedule 40, 2" PVC cap
5. Schedule 40, 1" PVC pipe
6. Treated  $\frac{5}{8}$ " plywood or a similar type of composite material (Starboard Poly-Sheets)
7. Brass hitch pins, 9" long
8. Brass locks (provided by the CPRA)
9. Spiral anchors, 4
10. L-brackets, 2" (hot-dipped galvanized or stainless steel)
11. Stainless steel or equivalent bolts,  $\frac{1}{4}$ "-20 x  $\frac{1}{2}$ "
12. Stainless steel or equivalent nuts,  $\frac{1}{4}$ "-20 x 1"
13. Marine caulk and adhesive

#### *Tools:*

1. Drill
2. Drill bits:  $\frac{7}{32}$ ",  $\frac{1}{4}$ ",  $\frac{9}{32}$ ",  $\frac{3}{8}$ ",  $\frac{1}{2}$ ",  $\frac{5}{8}$ ",  $\frac{3}{4}$ ", 1", 2- $\frac{3}{4}$ "

3. Tap, 1/4"-20
4. Hacksaw
5. Tape measure
6. Digital camera

*Construction:*

Mounting Base (Figure 3.9, A):

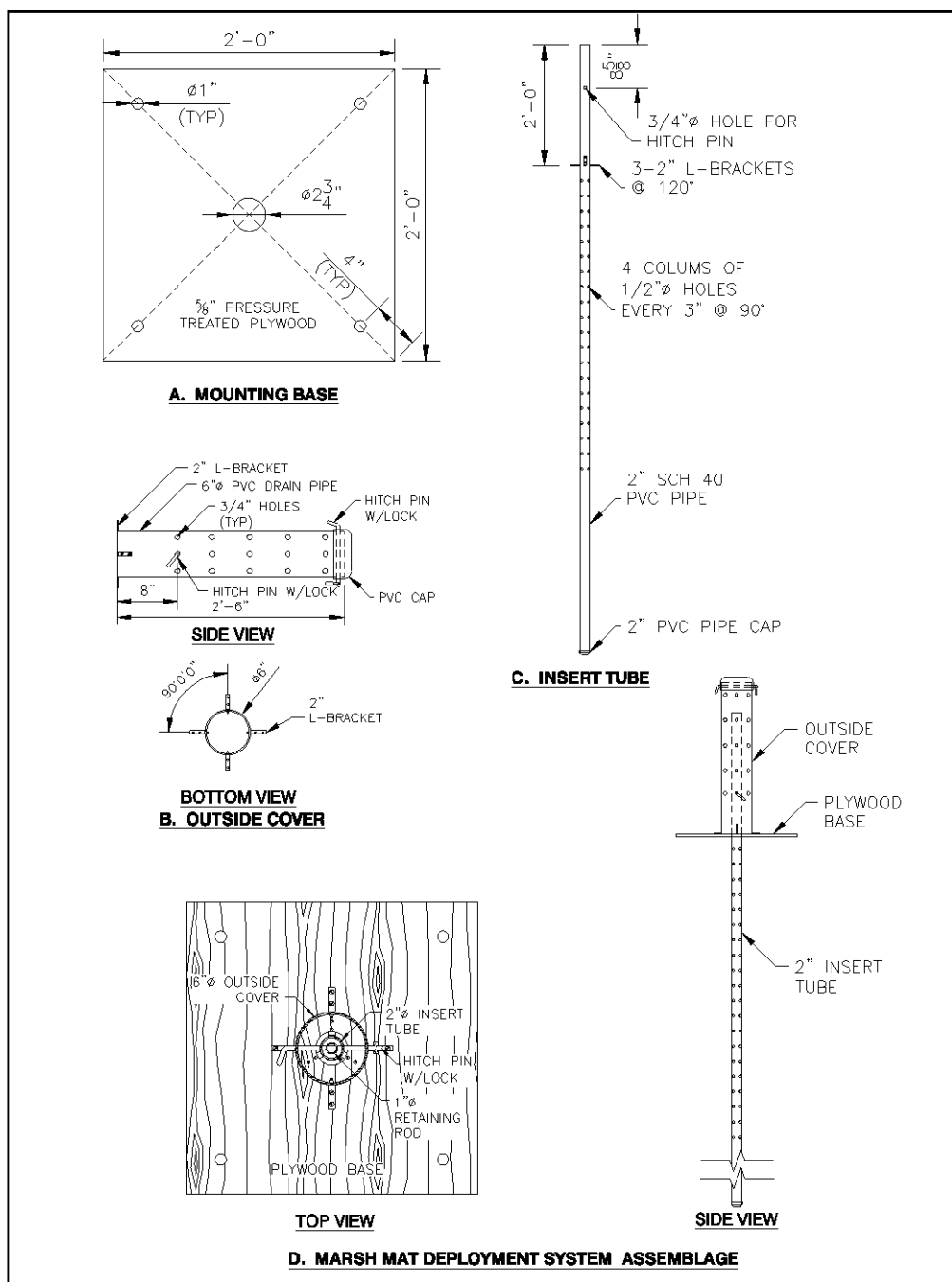
1. Cut plywood to measure 3 ft x 2 ft.
2. Draw lines diagonally from corner to corner to locate the center and locate the holes for the anchors.
3. Drill a 2-3/4" hole in the center of the board.
4. Drill 1" holes approximately 4" from each corner of the board along the corner lines.

Outside Cover (Figure 3.9, B):

1. Cut the 6" PVC pipe to a length of 30". Make sure the cut is square.
2. If the PVC pipe is not perforated, then drill a minimum of 20 (20) 3/4" holes in the pipe. Note: No holes shall be drilled 3" from either end of the pipe.
3. Place the 6" PVC cap on one end and drill a 3/4" hole through the assembly. This will enable a hitch pin to pass through the pipe and cap to lock the instrument.
4. Attach four 2" L-brackets on the opposite end of the 6" PVC pipe from the cap at 90 degrees from one another with the stainless steel or equivalent 1/4" x 20 x 1/2" bolts and nuts. Note: Holes on the brackets may need to be drilled with a 9/32" bit.

Insert Tube (Figure 3.9, C):

1. Take a 10-ft length of 2" PVC pipe and measure 24" from one end.
2. With the bottom of a 2" L-bracket on the mark and the top pointed towards the short end of the PVC, mark the mounting holes at 120 degree angles from one another.
3. Drill the 7/32" mounting holes with a drill press to ensure straightness.
4. Thread the 7/32" mounting holes with a 1/4" - 20 tap.
5. Drill out the holes on one leg of the L-bracket with a 9/32" drill bit.
6. Fill the tapped holes on the 2" PVC and coat the underside of the L-bracket with marine calking and adhesive.
7. Attach L-brackets (using the drilled-out holes) with the stainless steel or equivalent bolts (1/4" x 20 x 1/2").
8. Drill 1/2" holes in 4 rows 2-3" apart around the entire length of the pipe below the L-bracket.



**Figure 3.9.** Construction diagram for each individual component of the floating marsh mat recorder.

Mounting the Base, Insert Tube, and Outside Cover (Figure 3.9, D):

1. Align the insert tube so that it is centered in the 2- $\frac{3}{4}$ " hole in the mounting base and attach it to the mounting base using the L-brackets and the 1" stainless steel or equivalent bolts and nuts.
2. Align the outside cover over the insert tube so that it is centered around the insert tube on the mounting base. Attach the cover to the mounting base using the L-brackets and the 1" stainless steel or equivalent bolts and nuts.
3. Drill a  $\frac{3}{4}$ " hole through the outside cover and insert tube approximately 8" above the mounting base. Note: These holes will hold the hitch pin to be used for securing the instrument.

Retaining Rod:

1. Insert a 10-ft length of 1" PVC pipe into the insert tube so that approximately 3–4" is above the top of the insert tube.
2. Mark the 1" pipe in the center of the  $\frac{3}{4}$ " hole just drilled (step 3 above). Drill a  $\frac{3}{4}$ " hole through the pipe at the mark.
3. Put the pipe back into the insert tube and make certain that the locking hitch pin can be inserted through the outside cover, insert tube, and retaining rod.

*Field Installation:*

Tools:

1. Soil corer or auger, 3" diameter
2. Spiral anchors
3. Surveyor rod and/or measuring tape capable of measuring in feet, tenths, and hundredths
4. Hacksaw or PVC cutter
5. 2" PVC cap
6. PVC glue
7. Brass hitch pins, 2–9" long
8. Brass locks, 2 (provided by the CPRA)
9. 2" x 10" or 12" x 10 ft treated board

Installation:

1. The station will be located a minimum of 10 ft away from the boardwalk either in the designated area shown in Figure 2.8 or where requested by the CPRA. Once the proper location for the station has been determined, shoot a "before construction" photo.

2. Place a board on the marsh surface to displace the weight of the person installing the equipment. If two people are establishing the station, use two boards.
3. With the soil corer or auger, cut a hole through the marsh mat, and remove the resulting soil materials from the site.
4. Measure the thickness of the marsh mat and record the measurement in a field notebook with the site name, number, and date.
5. Measure the distance from the bottom of the YSI 600LS or equivalent to the water sensor. Record in a field notebook the instrument make and model and the measurement.
6. Add the two measurements (steps 4 and 5) together.
7. With the measurement obtained in step 6, transfer the measurement to the 2" PVC pipe from the bottom of the plywood toward the end of the pipe (opposite end of the outside cover).
8. Cut the PVC pipe using the hacksaw or PVC cutter.
9. Glue the 2" PVC cap to the end that was cut in step 8.
10. Place the set-up in the hole such that the 2" pipe goes through the marsh mat and the outside cover remains above the marsh surface.
11. Secure the set-up to the marsh surface using the four spiral anchors through the four holes in the board at the corners.
12. Using the 1" pipe that was pre-drilled (step 3 of the Retaining Rod section), cut the pipe such that the YSI 600LS remains in place.
13. If the instrument is not being deployed at this time, lock the retaining rod into place using the brass hitch pin and lock. Then lock the 6" cap using the brass hitch pin.
14. To document proper installation, shoot an "after construction" photograph.
15. Complete all necessary information in the *Marsh Mat Recorder* section (#6) on the "CRMS Site Construction Sheet" (Figure 2.11).

With this installation method, the water level sensor on the continuous recorder will be located at the bottom of the marsh mat. The measurement from the marsh surface to the water level sensor is a crucial measurement, because when correlated to the water elevation data from an associated hydrologic station, it will be used to determine depth and duration of the flooding of the floating mat.

#### ► **Static system:**

The static system is used in thin-mat floating marshes that are unable to support the weight of the floating system. To measure vertical mat movements, the design uses a counterweight pulley that is attached to the marsh mat and a recorder instrument. The station contains an elevation mark, which is surveyed to a datum and used to calculate marsh elevation.

*Materials:*

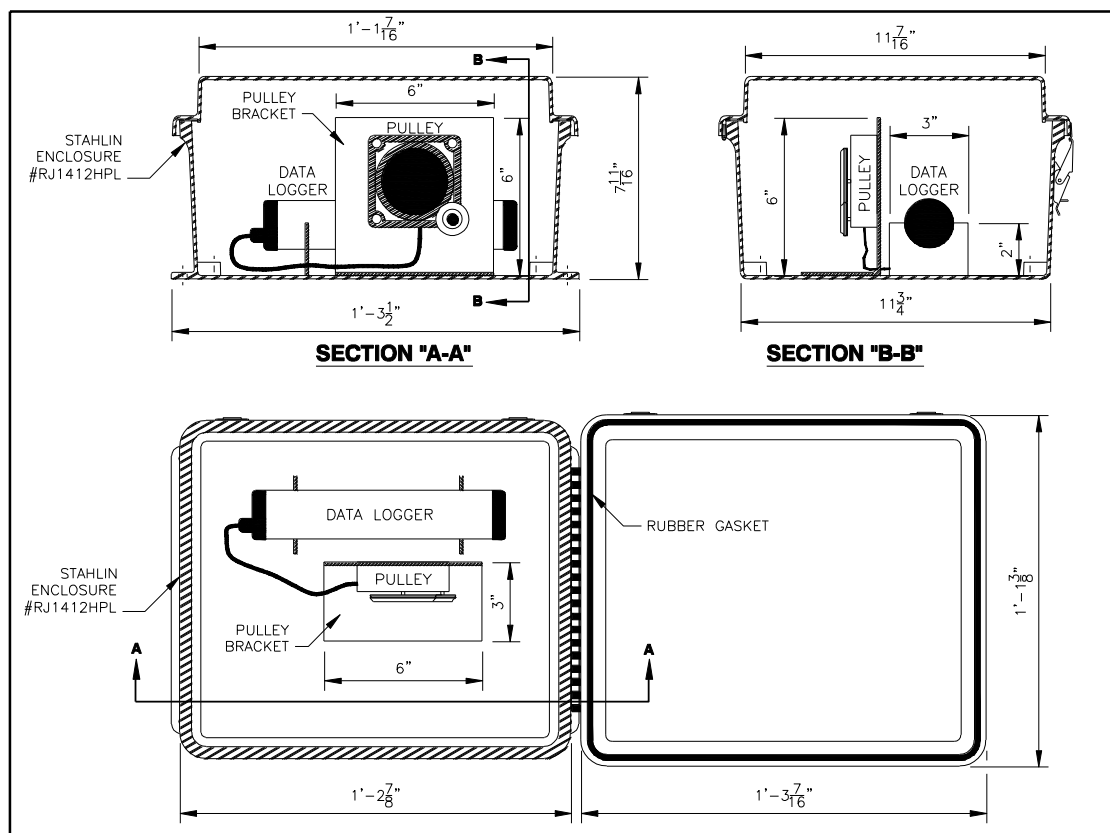
1. 1 – Schedule 40, 3" aluminum pipe, 20 ft in length
2. 3" Cap for the pipe
3. Housing unit - an aluminum pre-fabricated box that resembles the schematic in Figure 3.10 and is used to protect the recording equipment
4. Heavy-duty 15"–20" shelving bracket
5. 2 Self-drilling stainless steel screws; size is dependent on shelving bracket hole diameter but length should not interfere with cable inside of aluminum pipe
6. Adjustable stainless steel hose clamp for 3–3 ½" pipe

*Tools:*

1. 3" coring device
2. Pile driver
3. Drill and ¼" bit
4. Hack saw
5. Level
6. Surveyors rod
7. Digital camera

*Installation:*

1. The station will be located at the terminal end of the floating boardwalk section as shown in Figure 2.8, or where requested by the CPRA. Once the proper location for the station has been determined, shoot a "before construction" photo.
2. Cut a hole in the marsh mat the size of the post using a soil auger or coring tube, and place the post in the hole. The post shall be open on both ends and when installed shall remain high enough above the marsh surface (e.g., minimum of 4 ft above boardwalk), such that the counterweight does not rest upon anything in the tube during deployment or servicing. If the counterweight touches anything inside the post it may adversely affect the readings.
3. Push the post by hand into the underlying substrate as deep as possible while maintaining plumb.
4. Use the pile driver to drive the post into the substrate until resistance is met. A protective cap or covering should be used on the post to prevent damage from the pile driver. If damage occurs during the installation, cut the damaged portion off squarely so that the platform will rest perpendicular on the post.
5. Once the post is installed, drill a ¼" hole in the section of pipe closest to the boardwalk (i.e., that faces the boardwalk) approximately 8–10" from the top. This hole will serve as an elevation mark for the instrument.
6. Secure the housing unit to the top of the pipe and make sure that the arm and pulley are level.



**Figure 3.10.** Construction drawing for the instrument housing unit used on the static marsh mat continuous recorder system.

7. Attach the heavy duty shelving bracket such that the top of the bracket is even with the top of the  $\frac{1}{4}$ " hole using the two self-drilling screws and strap. Make sure the bracket is level and it is not directly beneath the arm extending from the housing unit.
8. To document proper installation, shoot an "after construction" photograph.
9. Complete all necessary information in the *Marsh Mat Recorder* section (#6) on the "CRMS Site Construction Sheet" (Figure 2.11).

#### 3.1.2.4 Staff Gauge Installation

The CPRA utilizes staff gauges with the following specifications: ceramic-coated gauge 2.5" wide ranging from -2 to +3 ft, graduated to hundredths, marked at every foot and every tenth, and five grommet holes for fastening with  $\frac{1}{4}$ " x 1  $\frac{1}{2}$ " stainless steel hexagonal screws with a slotted head. The gauge is mounted to a 2" x 4" x 6-ft treated board, which is then attached to a 4" x 4" treated wooden post or a 2" galvanized pipe



driven to resistance (Figure 3.11). The staff gauge will be set to the vertical datum NAVD88 (North American Vertical Datum) in feet during the surveying procedure.

When placed in proximity to a continuous recorder set-up, the staff gauge set-up should not be placed in a location where it may hinder the 2" x 4" board on the continuous recorder set-up from being swiveled fully for periodic servicing or inspections. In addition, the ceramic-coated gauge should be oriented so that it can be viewed easily from the continuous recorder station during servicing.

#### *Materials:*

1. 4" x 4" treated wooden post either 16 ft or 20 ft in length
2. Or 5-ft-long 2" galvanized pipe threaded on both ends
3. 2" galvanized couplings
4. 2" galvanized caps

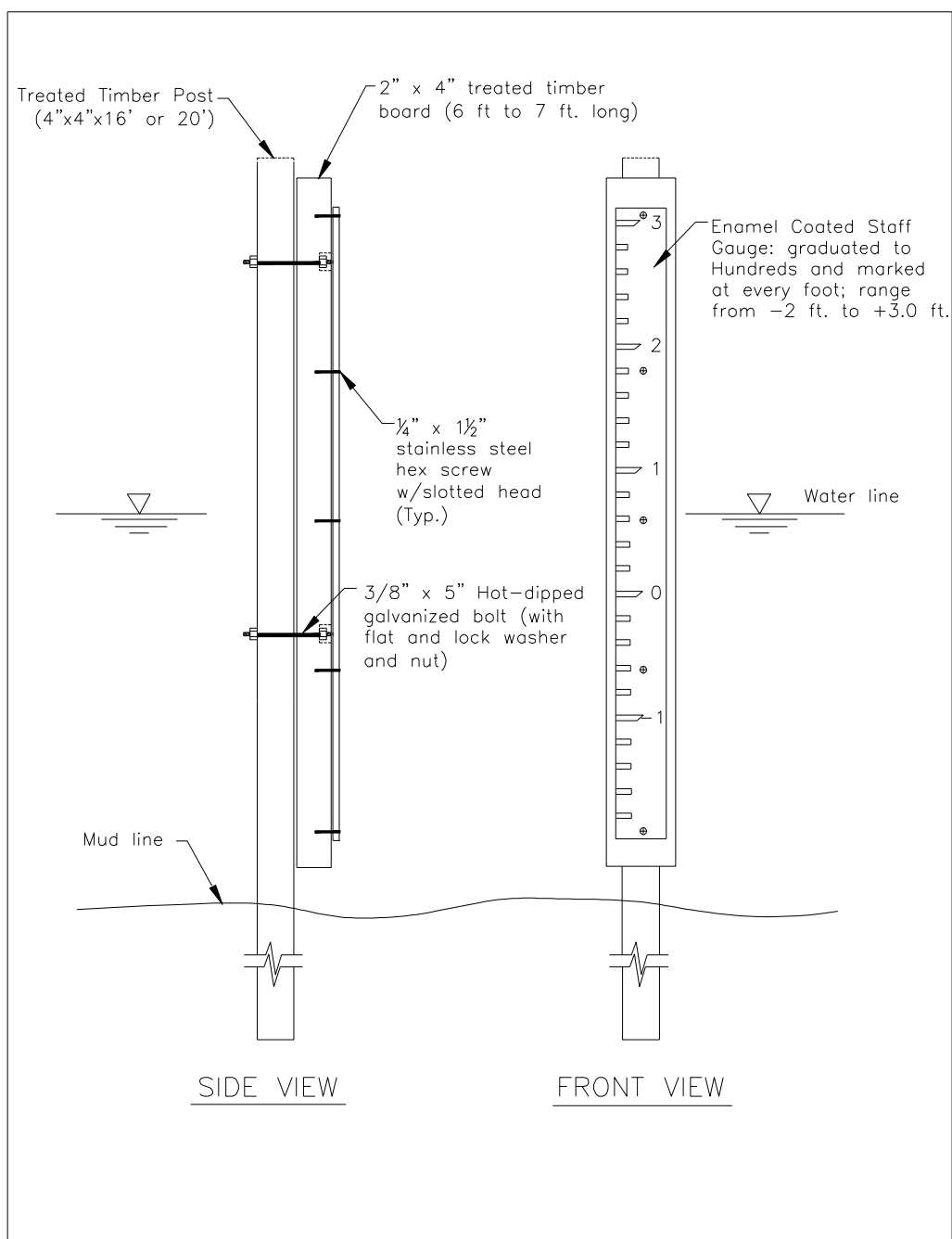
#### *Tools:*

1. 2 Pipe wrenches
2. Pile driver
3. Digital camera

#### *Installation:*

The procedures for installing the wooden post are the same as in section 3.1.2.1. The procedures for installing the pipe to resistance are as follows:

1. Determine the correct location for the staff gauge according to the approved PSV packet (Figure 2.2) or as directed by the CPRA, and shoot a "before construction" picture.
2. Connect two or more pieces of the pipe using the couplings and tighten with the wrenches.
3. Place the pipe in the water at the desired location and push the pipe into the substrate by hand, making sure the pipe remains plumb.
4. Continue to add sections of pipe as needed and tightening with the wrenches.
5. Once resistance has been achieved, loosely thread the 2" galvanized cap on the top pipe. The cap is used to prevent damage to the pipe threads while using the pile driver. The cap should be removed after each section of pipe is driven.
6. Continue to add sections of pipe and drive them in the same manner.
7. The process is complete when the pipe has met refusal and a minimum of 4 ft remains above the marsh surface.
8. Tighten the cap onto the end of the pipe.
9. To document proper installation, shoot an "after construction" photograph.



**Figure 3.11.** Typical staff gauge installation.

10. Complete all necessary information in the *Staff Gauge* section (#4) on the “CRMS Site Construction Sheet” (Figure 2.11).

### 3.1.2.5 **Surveying Procedures**

Elevations will be established at most CPRA sites. All elevations will be surveyed using the vertical datum NAVD88 in feet and will be referenced to the CPRA’s secondary benchmark network, which was established according to the methods described in the manual “A Contractor’s Guide to Minimum Standards” (CPRA 2011). Elevations shall be obtained using real-time kinematic (RTK) surveying technology for marsh sites; in swamps and other areas where RTK does not meet our accuracy specifications, alternative (e.g., conventional) methods will be used.

#### ► **Continuous recorder sites:**

##### *Marsh Sites:*

The purpose of the survey is to obtain the elevation of the top of the support post of the continuous recorder stations. This elevation, once obtained, will allow for the calculation of the “mark” (nail or hole) elevation located on the side of the support post. The “mark” elevation will allow for the depth data collected at each station to be converted to the same vertical datum (NAVD88 in feet).

The following survey procedures should be used:

1. Set up the RTK base station on a known GPS benchmark.
2. Set up the Rover unit in fixed mode and to begin receiving differential corrections, perform a quality assurance.
3. Check near the base station to confirm positions are being correctly delivered. Upon confirmation, carefully measure the Rover’s GPS antenna pole from the base of the antenna mount to the base of the bracket of the bulls-eye bubble and make a note of this value. Use value as the measured rover antenna height. The base of the bulls-eye bubble is more stable for performing shots on the gauge versus the point of the pole.
4. Place the base of the bulls-eye bracket of the RTK pole flush with the top of the 4” x 4” post directly above the nail or hole and enter the “Point Number” and feature code (top of 4” x 4” post), then select “Measure” in the “Topo Mode” on the data controller (should be about a 3–5 second measurement). Switch the measurement mode to “Observed Control” and enter the same point number, adding the letter “A” after it, and select “Measure.” Once the measurement has been taken (about 3 minutes), compare the elevation to the previous shot. If the elevation differs by more than 0.04 ft, retake the measurement until a satisfactory tolerance is attained.
5. Record both measured values in the field notebook and label appropriately.

6. Using a tape measure displaying feet, tenths, and hundredths, obtain and record the following distances:
  - a. Top of post to top of nail shank or top of ¼" hole.
  - b. Top of post to top of water.
7. Using the elevation obtained from the longer observation, calculate the elevation of the nail shank or hole and the water. Document these calculations (Figure 3.12).
8. Shoot photo for survey data sheet (Figure 3.13).

#### *Swamp Sites:*

The CPRA recognizes the difficulty of using the RTK method of surveying in a swamp environment. Surveying within swamp sites may require the use of two methods in order to establish elevations at the site. Surveying crews may be able to utilize the RTK method from the secondary monument to an area closer to the site where they can establish a temporary benchmark. From this temporary benchmark, conventional surveying may be necessary to establish the elevations at the continuous recorder post, set the staff gauge, and determine the elevation of the swamp floor. When utilizing the conventional survey method, all standard surveying practices should be followed.

If propagation errors occur due to the dense forest canopy, conventional elevation surveys may be performed as long as temporary benchmarks (TBMs) have been established using RTK methods. The TBM must be within the 3-mile radius of a Louisiana Coastal Zone (LCZ) GPS network secondary monument (SM) or another TBM that has been surveyed into this network. In addition, a level loop (single-run leveling) must be performed to minimize the effects of elevation misclosure when using optical instruments.

#### *Static Floating Marsh Mat Recorder System:*

In order to convert the data obtained from this instrument to a vertical datum, a ¼" hole is drilled within the top 12" of the pipe. The elevation of the top of the hole shall be determined by RTK surveying methods. A static floating marsh mat recorder system data sheet similar to the continuous recorder data sheet (Figure 3.12) shall be produced.

#### ► **Staff gauge:**

Staff gauges are surveyed to directly measure water elevation within a vertical datum. In addition, staff gauges are used for verification (quality control) of continuous recorder water elevation data. Gauges are mounted to a 2" x 4" x 6-ft board that will then be attached to a support post.

The following survey procedures shall be used:

1. Obtain an elevation of the top of the post or pipe using steps 1–5 in the above section for continuous recorders.

Continuous Recorder and Staff Gauge Survey Data Sheet

Station	Date	Continuous Recorder Gauge				
		Top of Recorder Support Pole (4x4 Post, Cap of Pipe, etc.)	Top of Support Pole to Nail or Top of 1/4" Hole	Nail or Hole Elevation	Top of Recorder Support Pole to Top of Water Distance	Water Elevation
		(NAVD 88, Ft.)	(Ft.)	(NAVD 88, Ft.)	(Ft.)	(NAVD 88, Ft.)

**How to Obtain Readings for Each Continuous Recorder Gauge Column**

**Top of Recorder Support Pole:** Obtained by using department approved surveying methods.

**Top of Support Pole to Nail or 1/4" Hole:** Obtained by physically measuring the distance between the two points.

**Nail or Hole Elevation:** Obtained by using the formula subtracting the two previous columns.

**Top of Recorder Support Pole to Top of Water Distance:** Obtained by measuring the distance between the two points.

**Water Elevation:** Obtained by using the formula: Top of Recorder Support Pole - Top of Recorder Support Pole to Top of Water Distance.

Station	Date	Staff Gauge						
		Existing Staff Gauge Reading (Upon Arrival)	Top of Staff Gauge Support Pole	Top of Staff Gauge Support Pole to Top of Water Distance	Water Elevation	Staff Gauge Reading (After Establishment or Adjustment)	Computed Difference (Water Elevation vs. Staff Gauge)	Correction Factor
			(NAVD 88, Ft.)	(Ft.)	(NAVD 88, Ft.)	(NAVD 88, Ft.)		

**How to Obtain Readings for Each Staff Gauge Column**

**Existing Staff Gauge Reading:** If a staff gauge is present at this location, obtain a reading before any adjustments are made.

**Top of Staff Gauge Support Pole:** Obtained by using department approved surveying methods.

**Top of Staff Gauge Pole to Top of Water Distance:** Obtained by physically measuring the distance between the two points.

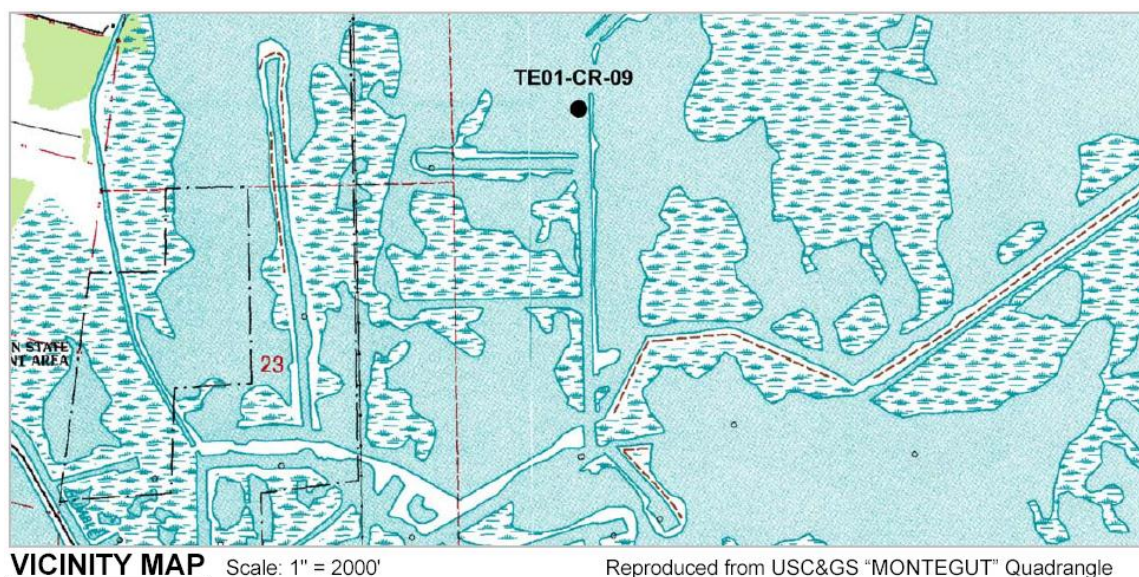
**Water Elevation:** Obtained by subtracting the two previous readings (Top of Staff Gauge Support Pole and Top of Staff Gauge Support Pole to Top of Water Distance).

**Staff Gauge Reading:** Obtained by reading the staff gauge after it has been set to the datum.

**Computed Difference:** Obtained by subtracting the two previous readings (water elevation and Staff Gauge Reading)

**Correction Factor:** Obtained by subtracting the Existing Staff Gauge Reading and the Staff Gauge Reading. The correction factor is used to correct all previously data collected.

**Figure 3.12.** Example of a surveying spreadsheet used to calculate correction factors for historical monitoring hydrologic data.



**Station Name: "TE01-CR-09"**

**Location:** From the boat launch along HWY 55 in Montegut, Louisiana, at the point Barre Road, head north in Bayou Terrebonne to the Humble Canal. Head southeast in Humble Canal to the Oilfield Canal. Turn left out of Humble Canal into the Oilfield Canal heading north. At the end of the Oilfield Canal is the Montegut Levee System with a set of boat rollers to allow for boats with engines smaller than 25 horsepower to cross. After crossing the levee follow the levee system heading easterly for approximately 4500 feet. Turn into the location canal heading north. The gage is located approximately 4000 feet from the levee system in the location canal.

**Gage Description:** The gage is a continuous recorder type gage attached to a 4 x 4 treated wood post with reference nail driven horizontally into the wood post.

**Date of Survey:** November 26, 2003

**CONTINUOUS RECORDER GAGE**

**Adjusted NAD 83 Geodetic Position**

Lat. 29°26' 54.097" N  
Long. 90°32' 22.825" W

**Adjusted NAD 83 Datum LSZ (1702) Feet**

N= 345,762.50  
E= 3,533,439.33

**UTM NAD 83 Datum Meters**

N= 3,260,181.697  
E= 738,632.323

**Elevation at Top of 4x4 Post**

Elevation = 5.83 feet (NAVD 88)

**Elevation at Top Shank of Nail**

Elevation = 4.12 feet (NAVD 88)



*Position determined by using Real-Time Kinematic (RTK) survey from Secondary GPS Monument "FLOOD"  
Position established by T. Baker Smith & Son, Inc. for the Louisiana Department of Natural Resources, Coastal Restoration Division.*

**Figure 3.13.** Example of a continuous recorder survey data sheet.

2. Calculate the 3-ft mark using the elevation of the top of post. Top of post elevation – 3.00 = Distance from top of post.
3. Using a tape measure, measure from the top of post where the RTK pole was positioned and place a mark at the distance calculated in step 2. This should be the 3.00-ft NAVD88 elevation.
4. From this mark, extend a level line on the side of the post.
5. Attach the staff gauge using two or three screws to the 2" x 4" board. The staff gauge should be positioned such that the bottom of the staff gauge is near the bottom of the board and that the board extends a few inches above the staff gauge.
6. Extend the 3-ft mark from the staff gauge to the same side of the 2" x 4" board that will align with the line drawn in step 4.
7. Clamp to the post the 2" x 4" with the attached staff gauge such that the two 3-ft lines match.
8. Measure the distance from the top of the post to the water.
9. Calculate the water elevation using the formula: Water elevation = Top of post elevation (obtained in step 1) – Distance (obtained in step 8).
10. The value calculated in step 9 should be the same value on the staff gauge. If not, then an error has occurred and must be corrected.
11. At the continuous recorder post, use the top of the post elevation from the continuous recorder, re-measure the distance to the water, and calculate the water's elevation.
12. The water elevation from the continuous recorder and the staff gauge reading should be within the error of the RTK instrument, which is  $\pm 0.05$  ft.
13. If all values are within tolerance, proceed with securing the staff gauge to the post by drilling a  $\frac{1}{2}$ " hole through the top of the 2" x 4" above the staff gauge and through the 4" x 4" post.
14. Unclamp and remove the board and staff gauge from the post.
15. Unscrew the two or three screws from the staff gauge and remove.
16. Place just the 2" x 4" board back on the post and secure with the  $\frac{3}{8}$ " x 6" bolt with washers and nut.
17. Drill another hole through the 2" x 4" and post as close to the water line as possible.
18. Remove the 2" x 4" and drill a hole to counter sink the bolt head. Note: The bolt head must be counter sunk completely to allow the staff gauge to be mounted flush to the board to prevent biofouling between the two from occurring.
19. Place the bolt in the hole that was drilled in step 17.
20. Attach the staff gauge to the 2" x 4" board using all five screws. Note: Do not overtighten the screws. Placing too much pressure on the staff gauge will chip the enamel coating and cause rusting.
21. Attach the board with staff gauge to the 4" x 4" post using the bolt, washers, and nut.
22. Check measurements again for insurance.
23. Shoot photos for documentation and survey data sheet.

Upon completion of the installation, obtain all the measurements that will complete the spreadsheet *Continuous recorders and staff gauge format for surveyor.xls* (Figure 3.12). These measurements verify that the staff gauge and the nail elevation are within the accuracy of the instrument. The difference between the water elevation reading with respect to the nail elevation and the staff gauge shall be within 0.05 ft of each other. If these readings are not within this range, elevations must be obtained and adjustments must be made until it is within the acceptable range. Also, a staff gauge data sheet shall be produced (Figure 3.14).

#### ► **Surface elevation:**

##### *Marsh Surface Elevation:*

Marsh elevation shall be determined at monitoring sites outside of the 10-m (32.8-ft) boardwalk buffer at a minimum of 20 points in attached marshes and swamps. Those areas that are classified as floating marshes shall not be surveyed. Elevations shall not be taken where there is an influence of spoil banks, levees, or any other human-induced alterations. In general, marsh surface with respect to elevation surveys is defined as “when the survey rod is resting among living stems or is supported by soil containing living roots.” In order to get a consistent reading, it will often be necessary to move stems in some marsh vegetation where stem density is extremely high. A minimum of 20 elevations recorded in relation to NAVD88 in feet (each one separated by 20 ft to 40 ft) are required at each site. The 20 elevations are averaged to obtain marsh elevation. All 20 readings and the average shall be recorded in an Excel spreadsheet identical to the format presented in Figure 3.15.

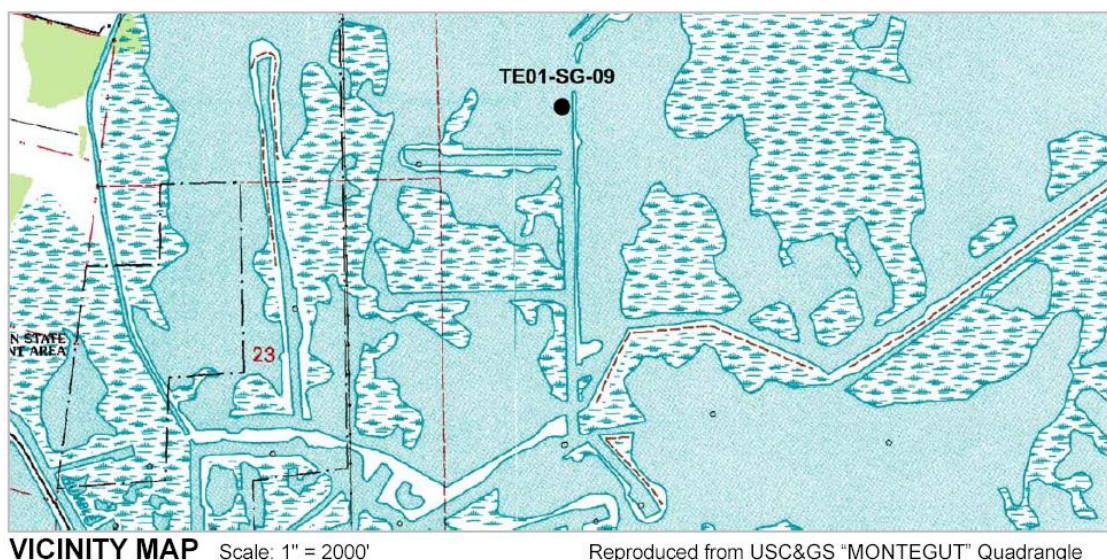
When the dominant species is *Spartina patens* (saltmeadow cordgrass), a minimum of forty (40) elevations will be recorded. Twenty elevations will be recorded on the marsh surface (as described above), and 20 elevations will be recorded on the crown/individual tuft (a small cluster of elongated flexible outgrowths attached or close together at the base and free at the opposite ends) of the *Spartina patens* that is adjacent to the marsh surface reading. These readings shall be recorded and labeled in the Excel spreadsheet as “marsh surface” or “*Spartina patens*.”

Once the survey at each station is completed, the surveyor shall record the type of terrain encountered during the survey. This should include whether the marsh was firm and easy to traverse, spongy with minimal difficulty, or very soft with extreme difficulty and holes in the marsh surface.

##### *Swamp Surface Elevation:*

The CPRA recognizes that swamp environments vary between regions, and that these differences must be considered when determining the actual surface of the





**Station Name: "TE01-SG-09"**

**Location:** From the boat launch along HWY 55 in Montegut, Louisiana, at the Pointe Barre Road, head north in Bayou Terrebonne to the Humble Canal. Head southeast in Humble Canal to the Oilfield Canal. Turn left out of Humble Canal into the Oilfield Canal heading north. At the end of the Oilfield Canal is the Montegut Levee system with a set of boat rollers to allow for boats with engines smaller than 25 horsepower to cross. After crossing the levee follow the levee system heading easterly for approximately 4500 feet. Turn into the location canal heading north. The gage is located approximately 4000 feet from the levee system in the location canal.

**Gage Description:** The gage is a ceramic plated staff gage mounted to a 2 x 4 attached to a 2.5" galvanized iron pipe.

**Date of Survey:** November 26, 2003

**STAFF GAGE**

**Adjusted NAD 83 Geodetic Position**

Lat. 29°26' 54.097" N

Long. 90°32' 22.825" W

**Adjusted NAD 83 Datum LSZ (1702) Feet**

N= 345,762.50

E= 3,533,439.33

**UTM NAD 83 Datum Meters**

N= 3,260,181.697

E= 738,632.323

**Elevation at Top of Galvanized Cap**

Elevation = 5.91 feet (NAVD 88)



*Position determined by using Real-Time Kinematic (RTK) survey from Secondary GPS Monument "FLOOD"  
Position established by T. Baker Smith & Son, Inc. for the Louisiana Department of Natural Resources, Coastal Restoration Division*

**Figure 3.14.** Example of a staff gauge survey data sheet.

## LA DNR Survey -- PROJECT NAME

**Station:** BA02-55

**Date and Time:** APRIL 23, 2003 & 10:30

**Staff Gauge Reading:** 1.58 FT.

**Marsh Flooded:** YES

Point Number	Easting (UTM_NAD83_METERS)	Northing (UTM_NAD83_METERS)	Elevation (NAVD88_FEET)
1	766,129.90	3,271,789.89	1.456
2	766,115.57	3,271,789.89	1.402
3	766,101.61	3,271,789.89	1.429
4	766,087.41	3,271,789.89	1.384
5	766,071.05	3,271,789.89	1.353
6	766,070.96	3,271,775.12	1.484
7	766,086.52	3,271,775.12	1.337
8	766,101.32	3,271,775.12	1.497
9	766,116.98	3,271,775.12	1.502
10	766,132.05	3,271,775.12	1.466
11	766,070.96	3,271,752.77	1.511
12	766,086.52	3,271,752.77	1.347
13	766,101.32	3,271,752.77	1.281
14	766,116.98	3,271,752.77	1.312
15	766,132.05	3,271,752.77	1.423
16	766,070.96	3,271,718.46	1.444
17	766,086.52	3,271,718.46	1.602
18	766,101.32	3,271,718.46	1.399
19	766,116.98	3,271,718.46	1.455
20	766,132.05	3,271,718.46	1.389
<b>AVERAGE MARSH ELEVATION</b>			<b>1.42365</b>
<b>MARSH ELEVATION</b>			<b>1.42</b>

### **NOTES / INSTRUCTIONS:**

1. Marsh elevation is the average of all the marsh shots.
2. Coordinate system must be properly labeled under the Northing and Easting headings.
3. Vertical datum must be properly labeled under the Elevation heading.
4. A new sheet must be generated for each station.

**Figure 3.15.** Marsh elevation survey data format.

swamp. In some areas where the swamp is seasonally flooded, the swamp surface may be easily determined, especially when there is no water above the surface of the swamp floor. For this type of environment, the swamp floor is determined “when the survey rod is resting among living stems or is supported by soil containing living roots.”

In an environment where the swamp is permanently flooded, some areas may or may not have aquatic vegetation that has rooted together to form floating marsh mats. Some areas may not have these floating marsh mats, but may have an environment where determining the swamp surface may be difficult due to a layer of unconsolidated materials and a spongy surface. Prior to surveying, the surveyor shall discuss with the CPRA a proposed method that shall be used at similar sites to consistently determine the swamp surface elevation at these sites.

#### **3.1.3 Initial Deployment of Continuous Recorders**

Prior to the initial deployment, the continuous recorder shall be programmed to record the date (mm/dd/yyyy), time (hh:mm:ss), water temperature (°C), specific conductance (µS/cm), salinity (ppt), water level (ft), and battery volts (v). The recorder must be programmed to record the time in Central Standard Time using the 24-hour system and must remain in that time configuration during Daylight Savings Time. Any data previously recorded on the instrument shall be deleted before initial deployment.

All procedures regarding the deployment of continuous recorder instruments in Section 3.1.3.1, Section 3.1.3.2, and Section 3.1.3.3, require the use of the electronic data sheet in Excel format titled “Continuous Recorder Calibration Sheet” (Figure 3.16), which is provided by the CPRA.

##### **3.1.3.1 *Open Water Deployment***

The following steps should be taken when deploying a continuous recorder in the open water environment:

1. Complete the *Station*, *Collected By*, *Agency*, *Calibration Instrument*, and *Serial Number* fields at the top of the calibration sheet. The *Collected By* and *Agency* names must be entered exactly as specified by the CPRA to be recognized by the CPRA’s database.
2. Complete the *Station Information* box on the calibration sheet. Three static measurements to be noted in this section include:
  - a. the *Mark to Sensor Distance (FT)*, which is the distance between the nail located on the wooden post or the top of the ¼” hole on the stainless steel pole to the water level sensor on the continuous recorder. This measurement will allow the water level readings to be converted to a vertical datum when the nail or top of ¼” hole has been surveyed by a professional, licensed surveyor.

<b>Continuous Recorder Calibration Sheet</b>				
Station	Collected By	Agency	Date & CS Time	
<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	
Calibration Instrument	Serial Number	Sonde Date & Time		
<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>		
Continuous Recorder	Serial Number	Battery Volts / %	Download Filename	Deployed Date and Time
<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>
<b>Station Information</b>		Mark Elevation (NAVD88, FT)	<input style="width: 90%;" type="text"/>	
Marsh Elevation (NAVD88, FT)	Mark to Sensor Distance (FT)		<input style="width: 90%;" type="text"/>	
<input style="width: 90%;" type="text"/>	If floating: Mat to Sensor Distance (FT)		<input style="width: 90%;" type="text"/>	
<b>Dirty Readings</b>		Sensor Elevation (NAVD88, FT)	<input style="width: 90%;" type="text"/>	
	Continuous Recorder	Calibration Instrument	Difference	% Difference
Temp. (°C)	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>
SpCond (µS/cm)	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>
Salinity (ppt)	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>
Depth (ft)	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>
<b>Post-Calibration Readings</b>				
	Continuous Recorder	Calibration Instrument	Difference	% Difference
Temp. (°C)	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>
SpCond (µS/cm)	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>
Salinity (ppt)	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>
Depth (ft)	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>
<b>Deployment</b>				
Continuous Recorder	Serial Number	Battery Volts / %	Desiccant Changed	
<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	
Deploy Filename	Sonde Date & CS Time	Batteries Changed		
<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>		
<b>Notes:</b> (Note any communication problems, equipment damage, changes in Mark to Sensor distance, changes to 4X4 sonde setup, etc.)		<b>Biofouling:</b> <input style="width: 90%;" type="text"/>		
<div style="border: 1px solid black; height: 100px; width: 100%;"></div>		<b>Staff Gauge (NAVD88, FT):</b> <input style="width: 90%;" type="text"/>		
		<b>Marsh Flooded:</b> <input style="width: 90%;" type="text"/>		
		<b>Vegetation Condition:</b> <input style="width: 90%;" type="text"/>		
		<b>SAV:</b> <input style="width: 90%;" type="text"/>		
<b>Calibration Information:</b> (Note any problems/issues encountered during sonde calibration)				
		Water Level Relative to Marsh (FT)	<input style="width: 90%;" type="text"/>	
		Water Elev to Datum(NAVD88, FT)	<input style="width: 90%;" type="text"/>	
		Staff Gauge - Water Elev	<input style="width: 90%;" type="text"/>	
<b>Infrastructure Damage Assessment:</b> (Note any damage to sonde setup and/or other CRMS features)				

Figure 3.16. Continuous recorder calibration sheet.

- b. the *Mark Elevation (NAVD88, FT)*, provided by a professional surveyor
  - c. the *Marsh Elevation (NAVD88, FT)*, provided by a professional surveyor
- If any of these measurements are unavailable, “N/A” should be entered.
3. Calibrate the instrument’s water level sensor to zero (0) when it is out of the water prior to deployment. Follow the procedures in the owner’s manual for the specific instrument being used.
  4. Calibrate the continuous recorder and hand-held instrument’s salinity probe to a known conductivity standard that is similar to the ambient water salinity concentration at the time of deployment. Document the calibration and calibration standard in the *Notes* section of the calibration sheet.
  5. Verify that the continuous recorder has accepted the calibration by using the calibrated hand-held salinity meter (YSI 30 or equivalent):
    - a. Place the two salinity probes next to each other and lower them into the water to the deployment depth.
    - b. Record the water temperature, specific conductance, and salinity reading from both instruments in the *Post-Calibration Readings* section of the calibration sheet.
    - c. The specific conductance difference will automatically be calculated using the formulas:

Specific Conductance Difference = Calibration Instrument – Continuous Recorder

% Difference = (Specific Conductance Difference / Specific Conductance of Calibration Instrument) \* 100

If the percent difference is below 5%, then the instrument is successfully calibrated. If the percent difference is above 5%, then the instrument needs to be recalibrated or is malfunctioning. If the percent difference is still above 5% after two calibration attempts, then the instrument should be replaced. Steps 3 through 5 should then be repeated to calibrate the replacement instrument. All issues related to the calibration of the instrument should be noted in the *Calibration Information* section of the calibration sheet.

6. Once the continuous recorder is calibrated, place the instrument into position for deployment.
7. Once the continuous recorder has stabilized, record the depth of the water from the instrument onto the calibration sheet in the *Post-Calibration Readings* section.

Verify that the water depth reading is correct using the following method:

- a. Place a surveyor’s measuring rod (ft) at the *Mark to Sensor Distance* value at the nail on the timber post or the top of the ¼” hole on the “mono-pole.” This places the bottom of the rod (zero reading) at the same depth as the water level sensor on the continuous recorder.
- b. Read the water level on the rod and record the value in the *Post-Calibration Readings* section in the *Calibration Instrument* column in the *Depth* field.

- c. The difference between the water level on the rod and the depth reading from the instrument will automatically be calculated using the formulas:

Water Level Difference = Water Level on Rod - Continuous Recorder Reading

% Difference = (Water Level Difference / Water Level on Rod) \* 100

- d. If the percent difference is below 5%, then the instrument is calibrated. If the percent difference is above 5%, then the instrument needs to be re-calibrated or is malfunctioning.
8. Follow the owner's manual for setting the continuous recorder in an unattended mode. Complete all fields in the *Deployment* section of the calibration sheet, including:
- a. *Continuous Recorder*: The manufacturer and model number of the continuous recorder must be entered as in the following examples: YSI 600LS, YSI 6920, Hydrolab MS5, etc.
  - b. *Serial Number*: Enter the serial # of the continuous recorder. In the case of a Hydrolab, only the last five digits of the serial number are required.
  - c. *Deploy Filename*: The filename must be deployed and documented as in the following example: 061201H1, where 0612 represents the site number, 01 designates the month in which the file was established, H designates the station as hydrologic open water (W = marsh well, M = floating mat), and 1 represents the station number.
  - d. *Date & CS Time*: The actual date and time the instrument is deployed must be documented. All times must be in Central Standard Time (CST) and written in 24-hour time convention (e.g., 3:00 p.m. = 15:00) even during Daylight Savings Time (DST). This is 'watch time'.
  - e. *Battery Volts*: Enter the battery voltage at the time of deployment.
  - f. *Batteries Changed* and *Desiccant Changed*: Fresh batteries and desiccant should always be used during the initial deployment of the instrument. Therefore, a YES should be selected for both fields. Note: When securing the desiccant tube in the electrical box, make sure that the plastic tubing is free of sharp bends or kinks that could result in the collection of non-vented data.
9. Complete all necessary information in the *Notes* section of the calibration sheet, including the staff gauge reading (if applicable). If this is the first time a sonde is being deployed at a particular station, then "Initial Deployment" should be typed into the *Notes* box. If a sonde is being deployed after a station has been rebuilt, then "Station Rebuilt" should be typed into the *Notes* box.

After the initial deployment has taken place, the instrument needs to be serviced no earlier than 30 days after deployment and no more than 60 days after deployment unless otherwise stated or agreed upon by the CPRA. Sites experiencing high levels of biofouling may need to be serviced every 30 days or as needed. Some sites may be subject to special landowner restrictions, which may prohibit servicing trips during

certain times of the year (i.e., duck season). Trips should be planned to closely bracket these restricted periods to minimize the length of time between servicing.

#### **3.1.3.2 Marsh Well Deployment**

The procedures for deployment of continuous recorders at marsh well sites shall remain the same as the procedures for deployment in the open water body except for the following:

1. Servicing and deployment of the recorder will not take place from a water vessel. The marsh well set-up will be serviced from the CRMS boardwalk. Enter and exit the site without stepping on the marsh surface. Note: The exposed continuous recorder cable may be enclosed in a wire mesh sleeve to prevent damage by animals. The mesh covering will be provided by the CPRA.
2. When collecting calibration readings, do not disturb the unit inside the well. Connect the handheld unit to sonde and record the water temperature, specific conductance, salinity and depth in the appropriate boxes under Dirty Readings on the Continuous Recorder Calibration Sheet.
3. Remove sonde from well, clean and calibrate the sonde.
4. Place sonde back in well and let sonde stabilize for 3-5 mins.
5. Connect to unit and record the water temperature, specific conductance, salinity and depth in the appropriate boxes under Post Calibration Readings on the Continuous Recorder Calibration Sheet.
6. Place a surveyor's rod on the Nail (mark elevation) on outside of sonde post and record water on marsh in NAVD elevation (ft).
7. Record the salinity and depth of the surface water on the marsh adjacent to the well.

#### **3.1.3.3 Floating Mat Deployment**

##### **► Floating system:**

The procedures for deployment of continuous recorders at marsh mat sites using the floating system shall remain the same as the procedures for deployment in the open water body except for the following:

1. Servicing and deployment of the recorder will not take place from a water vessel. The floating mat set-up will be serviced from a 2" x 12" x 10-ft board placed on the marsh surface. These stations are located away from the boardwalk since the boardwalk prevents vertical movement of the marsh mat. Note: The exposed continuous recorder cable may be enclosed in a wire mesh sleeve to prevent damage by animals. The mesh covering will be provided by the CPRA.
2. Calibration readings from the continuous recorder and the YSI 30 or equivalent must be taken separately since both instruments will not fit in the insert tube simultaneously (see Section 3.1.3.1, #5).



- a. Place the recorder inside the insert tube and record the water temperature, specific conductance, and salinity in the appropriate boxes under the *Post-Calibration Readings* section in the *Continuous Recorder* column.
  - b. Remove the recorder.
  - c. Place the YSI 30 or equivalent inside the insert tube and record the water temperature, specific conductance, and salinity in the appropriate boxes under the *Post-Calibration Readings* section in the *Calibration Instrument* column.
3. The water in the insert tube is often disturbed with the placement and removal of the continuous recorder and the YSI 30, causing the percent difference to be greater than 5%. If water is available near the station, the post-calibration readings may be collected using the surface water to verify the instrument is not out of calibration.
4. At floating mat stations, the only information in the *Station Information* section of the calibration sheet will be the *Mat to Sensor Distance*. "N/A" should be entered in the remaining boxes.

► **Static system:**

The Ott–Thalimedes instrument is used to collect marsh elevation in areas where the marsh is classified as a thin mat floating marsh or where determined by the CPRA. These marsh mats are usually less than a foot thick. The Ott–Thalimedes instrument has two ways of communication: (1) inferred and (2) serial port cable. It is recommended that the instrument be hard wired for serial port communications. The manufacturer's instructions for wiring the instrument should be followed or procedures should be discussed with CPRA personnel. It is strongly recommended that field personnel become familiar with the instrument prior to using the instrument in the field.

Unlike the other continuous recorders, which store data into pre-arranged files, the Ott–Thalimedes can only store data into one location (file). During the servicing of the instrument, all of the data is downloaded or a segment of the data can be downloaded by date.

Once the pipe has been driven into the subsurface to resistance and the housing unit with the arm and pulley has been attached to the pipe, mount the pulley into the housing unit and assemble the counterweight to the cable, thread the cable around the pulley, and attach the cable to the spiral anchor. Then attach the anchor to the marsh surface.

The following steps should be taken for the initial deployment of the Ott–Thalimedes instrument: [Note: It is recommended that the instrument's parameters be set prior to field deployment.]

1. Using the instrument's manual, set the following parameters:



- a. Set the unit of measure to feet (ft).
  - b. Set the sample interval to hourly (01:00), unless directed otherwise.
  - c. Set the circumference of the pulley to 0.656.
  - d. Set the direction of pulley rotation to increase in value as the marsh level increases in elevation (this may require “moving” the cable to determine the proper rotation).
  - e. Set the measured value (*Meas. Value*) to the calculated marsh elevation at the time of deployment. This enables the instrument to record data relative to NAVD88.
  - f. Set the date and time to Central Standard Time (CST), written in 24-hour time convention (e.g., 3:00 p.m. = 15:00) even during Daylight Savings Time (DST).
  - g. Set all other settings to manufacturer recommendations.
2. Using the “Static Marsh Mat Recorder Calibration Sheet” (Figure 3.17), complete the *Station*, *Date & CS Time*, *Sonde Date & Time* (if time is off by more than 10 minutes, reset the instrument time), *Deployed Date & Time*, *Field Personnel*, *Agency/Company*, *Continuous Recorder*, *Serial Number*, and *Battery Volts* fields. The *Field Personnel* and *Agency* names must be entered exactly as specified by the CPRA to be recognized by the CPRA’s database. Note: Since this is the initial deployment, the *Download Filename* box will be empty.
3. Complete the *Station Information* box on the calibration sheet. Three static measurements to be noted in this section include:
  - a. the *Mark Elevation (NAVD88, FT)*, provided by a professional surveyor. If at the time of deployment the *Mark Elevation* is unknown, then the distance between the *Mark Elevation* and the marsh surface will be the *Mark Elevation*. This number will not change until the elevation of the mark is given by the professional surveyor. This allows for just one correction factor to be applied to all data that was collected prior to the surveyor’s information. Also, NAVD88 shall have a line through it to indicate that the value in the box is not NAVD88, but a relative value.
  - b. the *Mark to Marsh Surface Distance (FT)*, which is the distance between the top of the hole (mark) located on the support pole or the top of the shelving bracket to the marsh surface. Only the initial measurement is to be used for deployment of the station.
  - c. the *Marsh Elevation (NAVD88, FT)*, is the calculated elevation of the marsh using *Mark Elevation (NAVD88, FT) – Mark to Marsh Surface Distance*. Note: If this value is not NAVD88, then a line shall be drawn through the NAVD88.
4. The *Dirty Reading* box on the calibration sheet remains empty during the initial deployment.
5. Perform a “Pulley Precision Check”:
  - a. Using a pencil or permanent marker, place a very thin mark on the pulley and housing.
  - b. Align the two marks and record the instrument’s reading in the *Before* box under *Instrument Reading*.

- c. Rotate the pulley exactly one revolution; i.e., realign the two marks.
- d. Record the instrument's reading in the *After* box under *Instrument Reading*.
- e. Calculate and record the *Difference* and *% Difference* between the two readings using the following formulas:

Pulley Check Difference = "Before" reading – "After" reading

% Difference = (Pulley Check Difference / "Before" Reading) \* 100

If the percent difference is below 5%, then the instrument is calibrated. If the percent difference is above 5%, then the instrument needs to be replaced and sent in for servicing. Record a "Yes" or "No" in the *Acceptable* box depending on whether the instrument properly calibrated.

- f. Complete the *Deployment* box on the calibration sheet, including the *Continuous Recorder*, *Serial Number*, *Battery Volts*, *Battery Changed*, *Date & CS Time*, and *Instrument Set to Marsh Elevation* fields. Note: *Instrument Set to Marsh Elevation* means that the instrument is set to record the marsh elevation as NAVD88, ft because the surveyor provided the elevation of the hole.
- g. Set the instrument to read the marsh elevation using the manufacturer software or by rotating the pulley. Field personnel will have to hold the cable such that the pulley rotates freely so it can be set.
- h. Complete the *Notes* box on the calibration sheet.
- i. Prior to locking the box, verify that the cable is correctly routed around all three pulleys and the value is correct on the recorder.

### Static Marsh Mat Recorder Calibration Sheet

Station <input type="text"/>	Date & CStime <input type="text"/>	Sonde Date & Time <input type="text"/>	Deployed Date & Time <input type="text"/>
Field Personnel <input type="text"/>		Agency / Company <input type="text"/>	
Continuous Recorder Ott - Thalimedes	Serial Number <input type="text"/>	Battery Volts <input type="text"/>	Download Filename <input type="text"/>

**Station Information**

Mark Elevation (NAVD88, FT) <input type="text"/>	Mark to Marsh Surface Distance (FT) <input type="text"/>	Marsh Elevation (NAVD88, FT) <input type="text"/>
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**Dirty Reading**

Constant Recorder: Marsh Elevation (NAVD88, FT)

Calculations: Marsh Surface Elevation Difference       % Difference

**Pulley Precision Check** (performed every 3 months or when the battery is changed)

Known distance of pulley rotation	Instrument Reading	Difference	Acceptable
<input type="text" value="0.66"/> FT	Before <input type="text"/>	<input type="text"/>	<input type="text"/>
	After <input type="text"/>	% Difference <input type="text"/>	

**Deployment**

Continuous Recorder Ott - Thalimedes	Serial Number <input type="text"/>	Battery Volts <input type="text"/>	Battery Changed <input type="text"/>
Instrument Set to Marsh Elevation: <input type="text"/>		Instrument Reading (FT) <input type="text"/>	
Date & CStime <input type="text"/>			

**Notes:**

Cable on Pulleys at Time of Arrival: <input type="text"/>	Spiral Anchor Still in Proper Position: <input type="text"/>
Water Above Marsh Surface <input type="text"/>	Depth of Water On Marsh (FT) <input type="text"/>
Staff Gauge (NAVD88, Feet) <input type="text"/>	

**Figure 3.17.** Static marsh mat recorder calibration sheet.

### 3.1.4 **Servicing**

#### 3.1.4.1 ***Open Water Servicing***

The following steps should be taken when servicing and redeploying a continuous recorder in the open water environment, using the Continuous Recorder Calibration Sheet (Figure 3.16):

1. Calibrate the hand-held instrument before use and document the calibration solution used in the *Notes* section. Note: After calibration, discard the used calibration solution.
2. Upon arrival at the station, complete the *Station*, *Collected By*, *Agency*, *Calibration Instrument* and *Serial Number*, *Download Filename*, and *Deployed Date and Time* fields at the top of the calibration sheet.
3. Complete the *Station Information* box on the calibration sheet with the following:
  - A. the *Mark to Sensor Distance (FT)*, which is the distance between the nail located on the wooden post or the top of the 1/4" hole on the stainless steel pole to the water level sensor on the continuous recorder. This measurement will allow the water level readings to be converted to a vertical datum (NAVD88) when the nail or top of the 1/4" hole has been surveyed by a professional and licensed individual or company.
  - B. the *Mark Elevation (NAVD88, FT)*, provided by a professional surveyor.
  - C. the *Marsh Elevation (NAVD88, FT)*, provided by a professional surveyor.

If any of these measurements are unavailable, "N/A" should be entered.
4. Without disturbing the instrument, connect to the instrument using a laptop computer or a field instrument capable of interfacing with the recorder.
5. Record the date and time as Central Standard Time (CST) (24-hour convention) from the technician's watch in the *Date & CS Time* field and from the instrument in the *Sonde Date & Time* field. Note: If the difference between the two timepieces is greater than 10 minutes, then the instrument time needs to be reset to Central Standard Time (CST) (24 hr system).
6. Record the battery voltage reading from the continuous recorder in the *Battery Volts* field.
7. Stop the instrument from logging and download the data file as a .txt file.
8. If the instrument is out of the water upon arrival, field readings can be obtained by using surface water in a bucket to obtain the Dirty/Post Calibrations Readings. Depth readings can also be obtained within the bucket to record the Dirty and Post Calibration readings. Note: (Dirty/Post calibration depth readings in the air can also be recorded in the notes section and used to compare with the readings collected using the bucket).
9. Lower the hand-held salinity meter probe to a depth near the sensor of the continuous recorder.
10. In the *Dirty Readings* section, record an in situ "dirty" water temperature, specific conductivity, salinity, and depth from the display unit attached to the continuous recorder.

11. In the *Dirty Readings* section, record the readings from the hand-held salinity meter. This includes the water temperature, specific conductance, and salinity. The specific conductance *Difference* and % *Difference* will automatically be calculated in the calibration sheet using the formulas:

Specific Conductance Difference = Calibration Instrument – Continuous Recorder

% Difference = (Specific Conductance Difference / Specific Conductance of Calibration Instrument) \* 100

Note: If the percent difference is 5% or greater, then the data will be shifted during processing to account for biofouling.

12. Remove the continuous recorder from its secured position and place it in the water vessel.
13. In the top section of the calibration sheet, enter the manufacturer and model number of the instrument in the *Continuous Recorder* field, and the serial number in the *Serial Number* field.
14. Following the recommended cleaning procedures in the owner's manual, clean all sensors and the exterior of the instrument such that it is free of all biofouling agents.
15. Clean the inside and outside of the PVC tube or mono-pole to prevent the buildup of biofouling agents over time. Any barnacles, oysters, or other agents must be removed during each servicing trip. Note: For more thorough cleaning and inspection purposes, the PVC tube must be pivoted out of the water at least quarterly or as needed in higher biofouling areas. All biofouling agents should be removed and the holding bolt at the bottom of the PVC tube should be inspected for signs of deterioration.
16. Determine whether the battery power remaining in the instrument is sufficient to power the instrument until the next servicing. The batteries must be changed if there is one-third less than the full battery power remaining or if the same batteries have been in use for three months or longer. Please be aware that some instruments also contain an internal lithium battery, which must be changed every 24 months to accurately power the internal clock. Failure to do so may affect data quality.
17. Calibrate the salinity probe of the continuous recorder following the procedures in the owner's manual for the instrument. Use a standard that is closest to the specific conductance reading on the salinity meter.
18. Set the water sensor to zero (0.00) while the instrument is out of the water, following the procedures described in the owner's manual.
19. Lower the instrument back into its unattended position.
20. Lower the calibration instrument to the deployment depth of the continuous recorder.
21. Once the readings have stabilized, record the water temperature, specific conductance, and salinity of both instruments, as well as the depth of the

continuous recorder, in the appropriate boxes under the *Post-Calibration Readings* section.

22. As in step 11, the specific conductance *Difference* and % *Difference* will be calculated for the post-calibration readings. If the percent difference is < 5%, then the instrument does not need recalibration (proceed to step 23). If the percent difference is above 5%, then attempt to recalibrate the instrument. If the instrument does not calibrate, then replace the instrument with a spare unit. Steps 17 through 22 should be repeated to calibrate the replacement instrument.
23. Determine whether the water level data will require a biofouling shift and whether the calibrated water depth reading is reading correctly using the following method:
  - A. Place a surveyor's measuring rod (ft) at the *Mark to Sensor Distance* value at the nail on the timber post or the top of the ¼" hole on the "mono-pole." This places the bottom of the rod (zero reading) at the same depth as the water level sensor on the continuous recorder.
  - B. Read the water level on the rod and record the value in the *Calibration Instrument* column in the *Depth* field of both the *Dirty Readings* section and the *Post-Calibration Readings* section.
  - C. The difference between the water level on the rod and the depth reading from the instrument will automatically be calculated using the formulas:

$$\text{Water Level Difference} = \text{Water Level on Rod} - \text{Continuous Recorder}$$

$$\% \text{ Difference} = (\text{Water Level Difference} / \text{Water Level on Rod}) * 100$$

Note: If the percent difference in the *Dirty Readings* section is 5% or greater, then the depth data will be shifted for biofouling during processing.

- a. If the percent difference in the *Post-Calibration Readings* section is below 5%, then the instrument is calibrated. If the percent difference is above 5%, then the instrument needs to be re-calibrated or is malfunctioning.
24. Follow the owner's manual for setting the continuous recorder in an unattended mode and complete the *Deployment* section of the calibration sheet. Instructions are presented in the previous section (3.1.3.1. Open Water Deployment, # 9). In cases where an instrument is deployed twice in the same month, the file name for the second deployment shall end with a "B" rather than a "1" (e.g., 061201HB). Note: It is not necessary to delete the recently collected data from the sonde before monthly redeployment. On a yearly basis, however, the data must be deleted since the file names will repeat themselves.
25. Check the desiccant pack to see if it needs changing. It should be changed a minimum of every 60 days. Note: When replacing and securing the desiccant tube in the electrical box, make sure that the plastic tubing is free of sharp bends or kinks, which could result in the collection of non-vented data.
26. Secure the instrument and cable using the brass locks on the brass hitch pin and the electrical box on the wooden post. For the mono-pole set-up, secure the cap to the top of the pipe using the brass hitch pin and brass lock.

27. Notes shall be taken and documented in the *Notes* section of the calibration sheet. These notes shall include:

- A. Communication and/or equipment issues including probe failures, failure to connect to the continuous recorder, dead batteries, condition of the cable, water in the battery compartment, etc.
- B. Calibration information including the initial calibration of the YSI 30 or equivalent as well as problems with calibrating or recalibrating the continuous recorder.
- C. Severity of biofouling on the instrument: Select LIGHT or HEAVY.
- D. The staff gauge reading (NAVD88, ft), if available.
- E. Biological conditions in the area surrounding the site, including whether the marsh was flooded, details concerning the overall condition of the surrounding vegetation, and the presence or absence of SAV. Notes regarding the condition of the vegetation should include whether the vegetation was healthy, stressed, burned, senesced, etc. Evidence of herbivory should also be noted.
- F. *Infrastructure Damage Assessment* section: If the station is associated with a CRMS site, document if there has been any vandalism, deterioration, or other damage to the recorder set-up, boardwalk, accretion stations, vegetation stations, or anything associated with the data collection efforts at the site.
- G. Any significant changes in the marsh with respect to erosion, subsidence, movement, etc.
- H. If the instrument is near a water control structure, document the flow direction of the water and approximate the speed of the water flow.

**TROUBLESHOOTING:** The continuous recorder will be removed from the field when the instrument malfunctions. Examples of such malfunctions may include, but are not limited to, inability to establish communication with the instrument, erroneous readings due to a malfunctioning sensor, or failure of the instrument to accept or hold calibration. Before removing the instrument from the field, several troubleshooting techniques shall be performed: 1) inspect the old batteries and compartment while changing the batteries and look for exploded batteries, acid and/or corrosion; 2) carefully clean all the sensors and attempt to calibrate; 3) check the cable connections between the continuous recorder and field display instrument; and 4) change the cable. If the continuous recorder is still malfunctioning, remove the existing instrument and replace it with a new instrument. Document this replacement in the *Deployment* section and follow the deployment procedures listed above. If a malfunctioning instrument belongs to the CPRA, the instrument shall be returned to the CPRA field office responsible for the station accompanied by a written description of the malfunction.

**CHANGES IN MARK TO SENSOR DISTANCE:** The *Mark to Sensor Distance* may have to be remeasured for various reasons, including physical changes to the station or a change in sonde type (Table 3.2). For example, if it is determined that any sensor is resting in the sediment and causing erroneous readings, then the instrument needs to be raised.

This will cause the *Mark to Sensor Distance* to change, which will affect the conversion of the depth data to the vertical datum (NAVD88, ft). The following procedures should be used in cases where the *Mark to Sensor Distance* changes during a servicing trip:

The original measurement should remain in the *Station Information* box on the calibration sheet. The new *Mark to Sensor Distance* should be noted in the *Notes* box and entered into the *Station Information* box during the next servicing trip.

The “water level on rod” reading used to determine the water level shift must be taken using the original *Mark to Sensor Distance* (see Section 3.1.4.1, #23). Therefore, the reading can be compared to the ‘dirty’ sonde depth reading.

The “water level on rod” reading used to confirm calibration must be taken using the new *Mark to Sensor Distance* in order for the depth to be compared at the new sensor location.

Any additional notes regarding changes to the *Mark to Sensor Distance* should be made in the *Notes* box of the calibration sheet.

Note: On the data sheet, the time to be used is the time from the sonde servicing personnel's watch (CST) in all time boxes except the “Sonde Date/Time” box at the top of the data sheet.

**Table 3.2.** Total instrument length (ft) and distance from bottom to depth sensor (ft) for the most commonly used continuous recorder models.

Instrument Type	Total Instrument Length (ft)	Distance from Bottom to Depth Sensor (ft)
Hydrolab MS5	2.23	0.46
YSI 600LS	1.46	0.33
YSI 600XLM	1.81	0.57
YSI 6920	1.54	0.64
Insitu	1.40	0.06

### 3.1.4.2 Marsh Well Servicing

The changes noted in Section 3.1.3.2 regarding the initial deployment of continuous recorders at marsh well sites also apply to the servicing and redeployment of marsh well sites in addition to the following:



Dirty readings should not be taken with the YSI 30 or equivalent to determine the biofouling shift because only raw specific conductivity and salinity data are required at marsh well sites. However, procedures for determining the depth data shift will still be followed.

All other procedures regarding the servicing of continuous recorders at marsh well sites will remain the same as the procedures for open water stations.

#### **3.1.4.3      *Floating Mat Servicing***

##### **► *Floating system:***

The changes noted in Section 3.1.3.3 regarding the initial deployment of continuous recorders at floating marsh sites also apply to the servicing and redeployment of floating marsh sites. All other procedures regarding the servicing of continuous recorders at floating mat sites will remain the same as the procedures for open water stations.

Additional comments should be made in the general *Notes* section associated with the condition of the floating mat site. Briefly describe the condition of the area with respect to any noticeable changes that may have occurred since the last trip. Document the water level in relation to the marsh surface and an estimate of how many inches above or below the marsh surface the water level is at the time of servicing. In the *Infrastructure Damage Assessment* section, document any vandalism or other damage to the recorder set-up, boardwalk, accretion stations, vegetation stations, or anything associated with the data collection efforts at the site.

The board which supports the floating mat set-up should be checked monthly to ensure that it is not sinking into or through the marsh mat layer, a condition which is more likely to occur in thin mat conditions. The station should also be checked to ensure that significant amounts of detritus are not collecting on top of the board. Stations experiencing these problems may need to be relocated every 12–18 months to ensure data accuracy.

##### **► *Static system:***

The following procedures shall be used when servicing a marsh mat station using the static system:

- a. Prior to leaving the office, the “Static Marsh Mat Recorder Calibration Sheet” (Figure 3.17) should be printed and the following boxes should be filled out: *Station, Deployed Date and Time, Agency/Company, Download Filename, and Mark Elevation.*
- b. In the field, prior to accessing the floating portion of the boardwalk, perform a visual inspection of the pipe, housing, cable going to the marsh, and the spiral

anchor (if it is not obscured by plants). Record any issues in the *Notes* section of the calibration sheet.

- c. Prior to unlocking the box for access to the instrument, inspect the cable at the end, the spiral anchor, and verify that the shelving bracket is still in the correct location (top of bracket is aligned with the top of the hole). Note whether the cable is off of the pulley, which will affect readings, and whether the spiral anchor is in a different position than when it was deployed.
- d. Access the instrument (OTT-Thalimedes) and inspect the pulleys inside the box. Note whether the cable is off of any of the pulleys.
- e. Connect to the instrument and download the data for the time period since the initial deployment or previous servicing. Note: Field personnel may want to download all the data to ensure the entire date range was downloaded. After 13 months of data collection, all data shall be downloaded and saved as a backup file. Once this backup file is verified to be downloaded, erase the data storage on the OTT-Thalimedes.
- f. Measure the distance from the top of the shelving bracket to the top of the marsh surface and record that value in the *Mark to Marsh Surface Distance (FT)* box.
- g. Calculate and record the *Marsh Elevation* in the *Station Information* section using the following formula:

$$\text{Marsh Elevation (NAVD88, ft)} = \text{Mark Elevation (NAVD88, ft)} - \text{Mark to Marsh Surface Distance (ft)}$$

- h. Record the instrument's reading for *Marsh Elevation* in the *Dirty Reading* section.
- i. Calculate the *Marsh Surface Elevation Difference* and *% Difference*.
- j. Change the battery if needed. The battery shall be changed when the battery volts drop to 1.1 volts, or yearly. A typical 1.5-volt battery may last 14 months before requiring a change. A pulley check shall be performed each time the battery is changed. If the battery does not need changing then the pulley precision check shall be performed every three months.
- k. Set the instrument for deployment.
- l. Verify the spiral anchor is securely attached to the marsh mat.
- m. Verify the cable is properly positioned on all pulleys.
- n. Verify the instrument is reading the current calculated marsh elevation.
- o. Complete the *Deployment* section of the calibration sheet.
- p. Complete the *Notes* section of the calibration sheet.
- q. Secure the station.

### 3.1.5 Data Processing

#### 3.1.5.1 *Processing of Open Water Data*

The CPRA has implemented a two-phase protocol for data processing. These two phases are referred to as data entry (Phase I) and quality assurance/quality control (QA/QC) (Phase II). These two phases are conducted by separate individuals to assure that the final product is in 100% agreement with the data collected during the field sampling procedure.

**DATA ENTRY (PHASE I):** Phase I is conducted by the individual responsible for the field data collection and requires three main tasks: 1. calibration sheet review, 2. data processing, and 3. data verification. These tasks require specific procedures necessary to satisfy the deliverable requirements. Below are the procedures for each task.

1. Calibration Sheet Review
  - a. Review the calibration sheet for completeness and accuracy.
  - b. Describe and document major changes to the calibration sheet in the *Notes* section. Minor corrections, such as the correction of typographical errors, do not need to be documented.
  - c. Whether or not a digital calibration sheet is used in the field, the sheet will need to be transformed into a specified digital .csv (comma-separated value) format for entry into the CPRA SONRIS database. A template will be provided and a file conversion tool is available if desired.
2. Data Processing
  - a. The data processing phase involves the use of the CPRA remote data load protocol. To properly process the data from its field format to its final QA/QC format, three files are needed:
    - i. The raw data file downloaded from the continuous recorder in .txt format. The filename should remain in the same format as the downloaded filename (example: 061201H1.txt).
    - ii. The associated post-review electronic calibration sheet (.xls) as named in the following example: 061201H1 Calibration Sheet.xls. This template has already been developed by the CPRA and will be provided.
    - iii. An Excel “data processing” workbook file, following a template that has already been developed by the CPRA and will be provided. You will transfer the raw data from the .txt file into this, as well as information from the calibration sheet (xls) file.
  - b. The “data processing” workbook file contains three worksheets:
    - i. “Data”: You will populate this worksheet with information from the calibration sheet and with the raw data from the continuous recorder. Formulas in this sheet will apply the biofouling shift to the

data if needed. The top area of the sheet contains fields for information from the field Calibration Sheet, and the lower area of the sheet, beneath the row of parameter headers, is for the raw and adjusted (shifted) data from the continuous recorder. Once you've populated the "Raw" data columns, the "Adjusted" data columns will auto populate with salinity and water level data adjusted (shifted) to account for biofouling and with water level data adjusted (shifted) and converted to NAVD88 (in ft). Auto-generating statistical summaries and percent completeness calculations are located to the far right side of the worksheet (to the right of the raw & adjusted data).

- ii. "Oracle": This worksheet puts the data from the "Data" worksheet into the appropriate format (Figure 3.18) for the CPRA main database.
- iii. "Graphs": This worksheet will display two graphs of your data. One graph shows the shifted salinity data and the shifted water elevation data to a vertical datum (NAVD88, ft). The other graph shows the depth and duration of flooding by overlaying the shifted water elevation (NAVD88, ft) with the marsh elevation (NAVD88, ft).
- c. Transfer the raw data from the .txt file and the necessary information from the calibration sheet file into the appropriate fields of the "Data" worksheet of the "data processing" workbook file. Verify that all data and calibration sheet information were imported correctly. Also verify that the biofouling shift was applied correctly, if needed. If the percent difference was greater than 5% between the dirty continuous recorder readings and the calibration instrument for the salinity or water level data, then a shift should have been applied in the "Adjusted" data columns.
- d. Make a visual check of the raw and adjusted (shifted) data by inspecting the "Data" worksheet and the graphs. If any erroneous data need to be deleted, always delete the data from the ADJUSTED (shifted) columns—never delete data from the RAW columns. In the "Oracle" worksheet, provide a brief explanation in the "Comments" column in all rows where data are voided (deleted). Erroneous data include, but are not limited to, these examples:
  - i. **NEGATIVE ADJUSTED VALUES:** In very low salinity or low water conditions, a biofouling shift in the negative direction may cause some ADJUSTED (shifted) values to be negative. In this case, the negative ADJUSTED (shifted) values should be deleted.
  - ii. **NEGATIVE RAW DEPTH:** Raw depth should never be negative. If negative raw depth values are encountered, there was either an instrument malfunction or the water level may have dropped below the depth sensor during the sampling period, resulting in erroneous readings. In the case of low water levels: whenever the raw water

level reading is 0.03 ft or less, the corresponding ADJUSTED (shifted) data must be deleted.

- e. Insert date/time spacers for any missed readings. Missed readings may occur due to instrument servicing, instrument malfunction, or battery failure. If this occurred, insert the missing rows into both the “Data” worksheet and the “Oracle” worksheet. Enter the missing date, time, and organization name into the appropriate columns, as well as a brief explanation for the missing data in the “Comments” column. All other columns for these “missing data” rows should remain blank.
- f. Use the “Graphs” worksheet to inspect the transition between the data in the previous month’s file and the data in the current file. Compare the last two weeks of data from the previous file (if one exists) to the data in the beginning of the current file to verify that the transition is smooth, the pattern is similar, and there are no missing data. If the transition between the two files appears erroneous, then the technician must attempt to resolve the problem by examining the data and the calibration sheet associated with the files. In some cases, a bad transition between datasets will reveal problems with the biofouling shift in the previous data set.

#### 3. Data Verification

- a. Upon completion of steps 1 and 2, double-check the data processing workbook file for accuracy. In addition to examining the transition between the datasets, compare the first data line to the previous calibration sheet to verify that the data are similar to the data collected by the instrument during the post-calibration readings. Examine the last data line to verify that the data are similar to the data collected on the current calibration sheet. If a shift was applied to the salinity and water level readings, it must be determined if this shift is accurate with respect to what was collected in the field.
- b. Upon completion of the review of the data, provide all associated electronic files to another individual for further examination and verification. This individual is referred to as the QA/QC officer. These files should include the raw data file (.txt), the calibration sheet files (.csv version and the hardcopy/digital xls from field), and the newly processed data processing workbook file (.xls).

### 3. Hydrologic Data

Station ID	Date (mm/dd/yyyy)	Time (hh:mm:ss)	Sensor Environment	Raw Water Temperature (°C)	Adjusted Water Temperature (°C)	Raw Specific Conductance (uS/cm)	Adjusted Specific Conductance (uS/cm)	Raw Salinity (ppt)	Adjusted Salinity (ppt)	Raw Water Level (ft)	Adjusted Water Level (ft)
CRMS0006-H01	02/22/2008	11:00:08	Surface Water	18.99	18.99	10959.70	10959.70	6.24	6.23	3.12	3.12
CRMS0006-H01	02/22/2008	12:00:08	Surface Water	18.85	18.85	10919.90	10919.90	6.22	6.21	3.08	3.08
CRMS0006-H01	02/22/2008	13:00:08	Surface Water	19.49	19.49	10973.30	10973.30	6.25	6.24	3.04	3.04
CRMS0006-H01	02/22/2008	14:00:08	Surface Water	20.39	20.39	10932.30	10932.30	6.22	6.22	3.02	3.02

(continued...)

Raw Water Elevation to Marsh (ft)	Adjusted Water Elevation to Marsh (ft)	Raw Water Elevation to Datum (ft)	Adjusted Water Elevation to Datum (ft)	Raw Battery (V)	Adjusted Battery (V)	Raw Marsh Mat Elevation (ft)	Adjusted Marsh Mat Elevation to Datum (ft)	Raw Wind Speed (mph)	Adjusted Wind Speed (mph)	Raw Wind Direction (degrees)	Adjusted Wind Direction (degrees)
	-0.27		0.83	5.20	5.20						
	-0.32		0.79	5.20	5.20						
	-0.35		0.75	5.30	5.30						
	-0.37		0.73	5.30	5.30						

(continued...)

Raw Velocity (ft/sec)	Adjusted Velocity (ft/sec)	Raw Precipitation (tips/hour)	Adjusted Precipitation (inches)	Raw Air Pressure (mm of Hg)	Adjusted Air Pressure (mm of Hg)	Raw Total Chlorophyll (micrograms/L)	Adjusted Total Chlorophyll (micrograms/L)	Raw Dissolved Oxygen (milligrams/L)	Adjusted Dissolved Oxygen (milligrams/L)

(continued...)

Raw pH (pH units)	Adjusted pH (pH units)	Raw Turbidity (NTU)	Adjusted Turbidity (NTU)	Raw Discharge (cubic ft/sec)	Adjusted Discharge (cubic ft/sec)	Organizati on Name	

**Figure 3.18.** Post-processing format of continuous hydrographic data.

**QUALITY ASSURANCE/QUALITY CONTROL (PHASE II):** Phase II begins when the QA/QC officer is provided the completed electronic files. The QA/QC officer should follow the steps below to ensure the data has been processed properly.

1. Examine the calibration sheet for completeness and accuracy.
2. Check the data from the calibration sheet to ensure it was correctly transferred into the “Data” worksheet of the Excel file.
3. Check that the starting/ending dates and times of the data within the Excel file correspond with the dates and times on the calibration sheets.
4. Ensure that there is no suspect data in the “Data” worksheet of the data processing workbook file, that all data have been shifted correctly, and that depth data were correctly converted to NAVD88, ft. Any missing data must be explained in the “Comments” column of the “Oracle” worksheet.
5. Check that the transition between the previous and current month’s data is smooth and that no sample point is missing between the two sample periods due to instrument servicing.
6. If mistakes are found, notify the data collector so any mistakes can be corrected or explained.
7. Continue this process until no mistakes are found.

A recommended QA/QC Checklist template is found in Figure 3.19 and is available as an Excel file (Hydrologic QAQC Checklist Form template 03022005.xls). However, printing and completing the QA/QC Checklist is not a requirement nor is it a deliverable. Once Phases I and II have been completed, open the .xls file and save the information in the “Oracle” worksheet as a .csv file. The Oracle worksheet .csv and the electronic calibration sheet .csv files are then loaded as a matched file-pair onto the CPRA FTP site using the naming conventions established during the deployment of the field file but the filenames must include the addition of the month that they were placed on the FTP site as the first two characters (example – **07**061205H1, where 07 is added as the month the file was placed on the FTP site the first time). Once the files are loaded, if the CPRA database detects any obvious errors in the files, notification emails will be sent to contractor personnel and the files will be rejected for correction and resubmission. If any files are corrected and reloaded, the corrected files must be named exactly the same as when they were first placed on the FTP site.

### 3. Hydrologic Data

HYDROLOGIC QA/QC CHECKLIST		
Project / Site Number: _____ Date discrete data collected: _____ QA officer: _____		
Data Collector: _____ Time period for continuous data: _____ Date approved: _____		
		QA Officer's Initials and Date
1	Was a field trip report generated ? <b>Y / N</b> COMMENTS:	
2	Were all data entered in datasheets correctly (i.e., data entered in correct columns, all data in correct units)? <b>Y / N</b> COMMENTS:	
3	Were discrete data entered correctly into Excel? Were any data missing? <b>Y / N</b> COMMENTS:	
4	Were continuous recorder calibration sheets entered correctly into Excel? <b>Y / N</b> COMMENTS:	
5	Were continuous data entered correctly into Excel (e.g., time, date, hydrographic data)? <b>Y / N</b> COMMENTS:	
6	Were specific conductance data shifted for biofouling? If not, list station # and recorder id #. <b>Y / N</b> COMMENTS:	
7	Were water level data shifted for biofouling? If not, list station # and recorder id #. <b>Y / N</b> COMMENTS:	
8	Were all water level data converted to a known elevational datum (outside of Oracle)? <b>Y / N</b> COMMENTS:	
9	Were data graphed? <b>Y / N</b> COMMENTS:	
10	Was there a normal transition between the last datum record and the present datum record? <b>Y / N</b> COMMENTS:	
11	Were different recorders deployed than retrieved? If so, was the Excel Recorder Deployment file updated? <b>Y / N</b> COMMENTS:	
12	Were discrete data entered correctly into SONRIS? Were any data missing? <b>Y / N</b> COMMENTS:	
13	Were continuous data entered correctly into SONRIS? Were any data missing? <b>Y / N</b> COMMENTS:	
		Final QA Officer's Initials and Date

**Figure 3.19.** Hydrologic QA/QC checklist.



### **3.1.5.2      *Processing of Marsh Well Data***

Procedures for the processing and QA/QC of data from marsh well sites are very similar to the procedures for open water stations. The main difference is that adjusted temperature, adjusted salinity, and adjusted specific conductivity data are not generated for these sites. All data in these columns should be deleted from the “data processing workbook” .xls file during processing, and it is not necessary to provide an explanation for this voided data in the “Comments” column of the “Oracle” worksheet. Raw data should never be deleted from the file. The data .csv file and the calibration .csv file should be loaded as a matched file-pair onto the CPRA FTP site using the naming conventions described for Open Water data. Once the files are loaded, if the CPRA database detects any obvious errors in the files, notification emails will be sent to contractor personnel and the files will be rejected for correction and resubmission. If any files are corrected and reloaded, the corrected files must be named exactly the same as when they were first placed on the FTP site.

### **3.1.5.3      *Processing of Floating Mat Data***

The processing of data collected at floating and static marsh mat stations is similar to the process used for open water stations. However, both marsh mat systems utilize water level data from a nearby open water or marsh well continuous recorder. In the floating system, the water elevation data (NAVD88, ft) from the nearby open water “reference” recorder, which contains a surveyed elevation mark, are used to convert the water level data from the floating mat recorder to a datum (Figure 3.20). The marsh surface elevation can then be converted to a datum by subtracting the elevation of the marsh surface from the converted floating mat water elevation (NAVD88, ft). In the static system, the water elevation data from the “reference” recorder are used together with the marsh surface elevation data from the static marsh mat recorder to determine marsh flooding.

The static system is different in that the instrument only records the date, time, and the raw marsh surface elevation. Raw battery volts, temperature, and salinity are not recorded. The instrument’s pulley system is calibrated to marsh elevation (NAVD88, ft) from the hole/shelving bracket elevation on the metal support post before the instrument begins data collection. Therefore, the raw marsh surface readings are already collected to a datum.

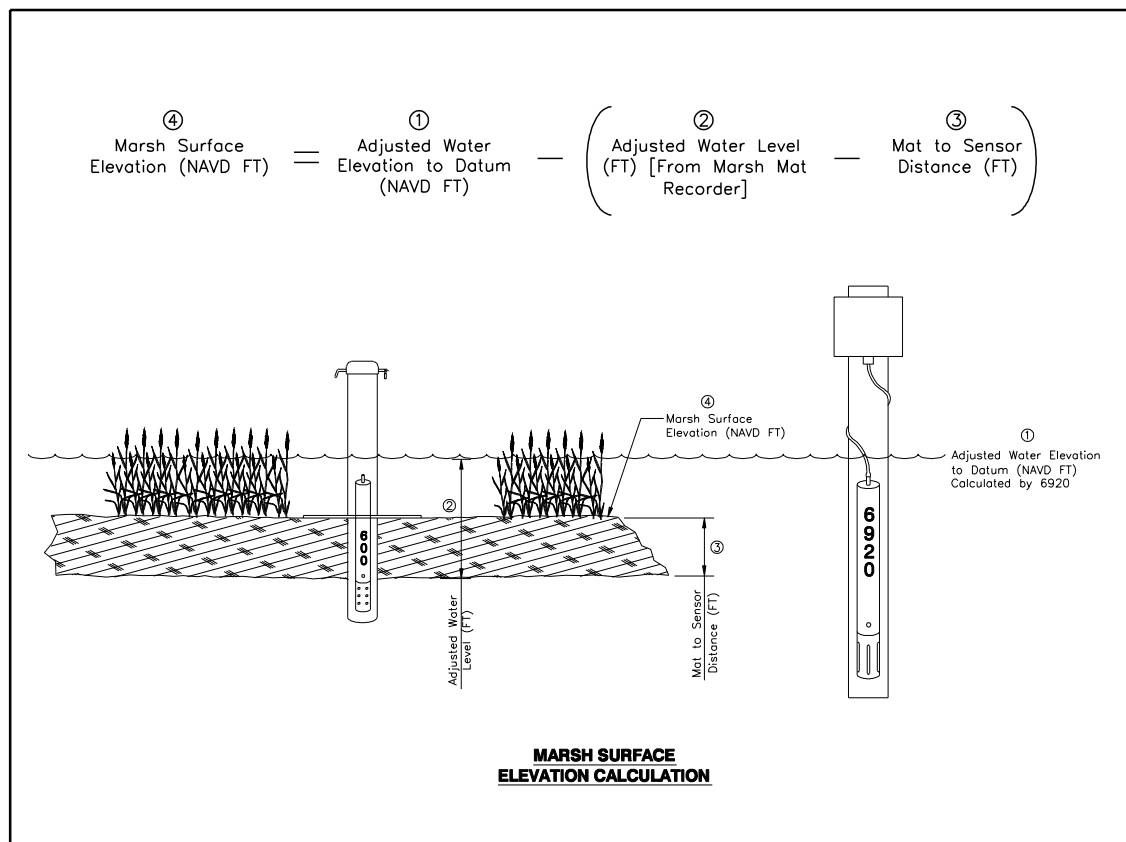
**DATA ENTRY (PHASE I):** Phase I is conducted by the individual responsible for the field data collection and requires three main tasks: 1. calibration sheet review, 2. data processing, and 3. data verification. These tasks require specific procedures necessary to satisfy the deliverable requirements. Below are the procedures for each task.

#### 1. Calibration Sheet Review

- a. Review the calibration sheet for completeness and accuracy.
- b. Describe and document major changes to the calibration sheet in the *Notes* section. Minor corrections, such as the correction of typographical errors, do not need to be documented.

#### 2. Data Processing

- a. To properly process the data from its field format to its final QA/QC format, six files are needed:
  - i. The raw data file in .txt format downloaded from the continuous recorder.
  - ii. The associated electronic calibration sheet (.xls) as named in the following example: 061201M1 Calibration Sheet.xls.
  - iii. The fully processed “data processing workbook” .xls file from the reference open water or marsh well continuous recorder. This file will be used to convert the depth data to NAVD88 in the floating system and to calculate marsh flooding in the static system.
  - iv. “Mat-QC” (floating system) or “Vertical Mat-QC” (static system) template (.xls) provided by the CPRA to import the raw data for shifting and quality assurance.
  - v. YearHour (.xls) file provided by the CPRA to verify date and times.
  - vi. Site History (.xls) template provided by the CPRA to document information regarding the station, data, or instrumentation at the site.



**Figure 3.20.** Schematic of the floating marsh mat continuous recorder set-up and the associated “reference” open water continuous recorder set-up.

- b. Print out the calibration sheet used in the field.
- c. Convert the raw .txt file to a comma-delimited text file (.csv).
- d. Open the Excel spreadsheet “YearHour,” provided by the CPRA and the newly created .csv file.
- e. In the comma-delimited text file, insert a column next to the date and time column and copy the appropriate time frame from the “YearHour” spreadsheet.
- f. Inspect the .csv file for any missing dates and times. If any dates and times are missing, add them in the appropriate places and leave the associated data cells blank. Note: If an hour was missing because of servicing, then it should be added to the end of the file.
- g. Open the template data processing workbook “Mat-QC.xls” or “Vertical Mat-QC.xls” (whichever is applicable) provided by the CPRA, and save it as an Excel file with the downloaded raw data file name and the .xls extension. This Excel template contains four worksheets:
  - i. “Marsh Mat Data”: This sheet contains information from the calibration sheet as well as the data from the continuous recorder. Formulas in this sheet will apply any necessary shifts to the data. The top area of the sheet contains data from the field calibration sheet (in red font), and the lower area of the sheet contains the raw data. Statistical summary and percent completeness calculations are located on the right side of the worksheet.
  - ii. “Sonde Data”: This worksheet contains the data from the reference open water or marsh well recorder located near the marsh mat recorder.
  - iii. “Marsh Mat Oracle”: This worksheet puts the data from the “Data” worksheet into the appropriate format (Figure 3.18) for the CPRA main database.
  - iv. “Graphs”: This worksheet contains graphs that are used to find outliers in the dataset as well as to view the trends of the environmental conditions with respect to salinity (floating system only), water elevations, and marsh surface elevations.
- h. In the “Marsh Mat Data” worksheet, change all the information in red font in the upper portion of the worksheet to correspond with the information on the calibration sheet.
- i. Copy the data from the .csv file containing the raw data from the marsh mat recorder. Paste the values into the appropriate cells on the lower section of the worksheet.
- j. Open the “data processing workbook”.xls file from the reference open water or marsh well station. Copy the data from the “Data” worksheet.
- l. Using the paste special feature, paste the data as values into the “Sonde Data” worksheet of the Marsh Mat “data processing workbook” file. Change all the red font information on the “Sonde Data” worksheet to

correspond with the information on the reference continuous recorder spreadsheet.

- m. Close all the files except the “data processing workbook” .xls file containing the floating or static marsh mat data.
- n. Delete the extra lines at the end of the “Marsh Mat Data” and “Marsh Mat Oracle” worksheets. The template is designed for larger datasets.
- o. Change the source data of the graphs on the “Graphs” worksheet so that the data extends the entire graph. Change the title of the graphs to correspond with the project name, station number, and dates of the data presented in the graphs.
- p. Examine the dataset and graphs for any erroneous data, and use best professional judgment to decide if any data need to be voided. If any erroneous data need to be deleted, always delete the data from the ADJUSTED (shifted) columns—never delete data from the RAW columns. In the “Marsh Mat Oracle” worksheet, provide a brief explanation in the “Comments” column in all rows where data are voided/deleted.
- q. Insert date/time spacers for any missed readings due to instrument servicing, instrument malfunction, or battery failure. Insert the missing rows into both the “Marsh Mat Data” worksheet and the “Marsh Mat Oracle” worksheet. Enter the missing date, time, and organization name into the appropriate columns, as well as a brief explanation for the missing data in the “Comments” column. All other columns for these “missing data” rows should remain blank.
- r. Examine the transition between the last two weeks of data from the previous file (if one exists) to the data in the beginning of the current file to verify that the transition is smooth, the pattern is similar, and there are no missing data. If the transition between the two files seems to be erroneous, then the technician must resolve the problem by examining the data and the calibration sheet associated with the files. In some cases, a bad transition between datasets will reveal problems with the shift in the previous dataset.
- s. In the “Marsh Mat Data” worksheet, change the heading of the Summary Statistics section to correspond with the project name, station number, dates, and times of the data.
- t. Update the Site History file with respect to all pertinent worksheets:
  - i. CR Deployment\_Removal: This worksheet tracks the make, model, and serial number of each continuous recorder at each station. When an instrument is removed from the field, complete the *Date Removed*, *Time Removed*, and *Notes* columns. Add another line containing the information for the newly deployed instrument. This provides a method for property control for the department with respect to the instrumentation.
  - ii. Recorder Elevations: This worksheet tracks any changes in the sensor elevation of the instrument and/or the *Mark to Sensor*

*Distance* that may have occurred for reasons such as a change in instrument type, station repairs, new survey information, etc.

#### 3. Data Verification

- a. Upon completion of steps 1 and 2, double-check the Marsh Mat “data processing workbook” file for accuracy. In addition to examining the transition between the datasets, compare the first data line to the previous calibration sheet to verify that the data are similar to the data collected by the instrument during the post-calibration readings. Examine the last data line to verify that the data are similar to the data collected on the current calibration sheet. If a shift was applied to the data, it must be determined if this shift is accurate with respect to what was collected in the field.
- b. Upon completion of the review of the data, provide all associated electronic files to another individual for further examination and verification. This individual is referred to as the QA/QC officer. These files should include the raw data file (.txt), the calibration sheet (.xls and .csv version), the completed “data processing workbook” files (.xls) for Marsh Mat and Reference Recorder, and the Site History file (.xls).

**QUALITY ASSURANCE/QUALITY CONTROL (PHASE II):** Phase II begins when the QA/QC officer is provided the completed electronic files. The QA/QC officer should follow the steps below to ensure the data has been processed properly.

1. Examine the calibration sheet for completeness and accuracy.
2. Check the data from the calibration sheet to ensure it was correctly transferred into the “Marsh Mat Data” worksheet of the Excel file.
3. Check that the starting/ending dates and times of the data within the Excel file correspond with the dates and times on the calibration sheets.
4. Check that the data from the reference open water or marsh well recorder was imported correctly into the “Sonde Data” worksheet. Also, check that the formulas in the “Marsh Mat Data” worksheet are referenced to the correct date/time reading in the “Sonde Data” worksheet.
5. Ensure that there is no suspect data in the file, that all data have been shifted correctly, and that depth data were correctly converted to NAVD88, ft. Any missing data must be explained in the “Comments” column of the “Marsh Mat Oracle” worksheet.
6. Check that the transition between the previous and current month’s data is smooth and that no sample point is missing between the two sample periods due to instrument servicing.
7. If mistakes are found, notify the data collector so any mistakes can be corrected or explained.
8. Continue this process until no mistakes are found.

Once Phases I and II have been completed, open the Marsh Mat “data processing workbook”.xls file and save the information in the “Marsh Mat Oracle” worksheet as a .csv file. The data .csv file and the calibration .csv file are then loaded onto the CPRA

FTP site as a matched file-pair, using the naming conventions established during the deployment of the field file, but the filenames must include the addition of the month that the files were placed on the FTP site as the first two characters. (Example – **07061205M1**, where 07 is added as the month the file was placed on the FTP site the first time.) Once the files are loaded, if the CPRA database detects any obvious errors in the files, notification emails will be sent to contractor personnel and the files will be rejected for correction and resubmission. If any files are corrected and reloaded, the corrected files must be named EXACTLY the same as when they were first placed on the FTP site.

#### **3.1.6 Continuous Data Deliverables**

##### **3.1.6.1 *Surveying Data***

All data collected under section 3.1.2.5, Surveying Procedures, shall be provided to the CPRA in the form of a survey report saved as a PDF, and Microsoft Word and Excel files. Survey reports include, but are not limited to:

1. a title page
2. a methodology report section including a description of the survey, location of the site, planning and layout of the GPS survey, data collection and processing summary, and quality assurance procedures
3. the marsh survey data sheet (.xls)
4. the completed Continuous Recorder and Staff Gauge Survey Data Sheet (.xls)
5. the RSET survey data sheet (if applicable)
6. a copy of the field notebook
7. the secondary benchmark data sheet

Prior to the composition of the survey report, it is recommended that a brief discussion occur for clarity.

##### **3.1.6.2 *Open Water and Marsh Well Data***

All files associated with the open water or marsh well dataset (see Sections 3.1.5.1 and 3.1.5.2) except for the .csv file will be provided to the CPRA through the *crms-contractor-information* on “*dnr-www2\wetlands\coastres*” FTP site. This includes:

1. the raw data file (.txt)
2. the processed “data processing workbook” file (.xls)
3. the calibration sheet (.xls)

The .csv data file and the .csv calibration file will be provided to the CPRA through the *crms* on “*dnr-www2\ftp\users*” FTP site to be automatically loaded as a matched file-pair into the SONRIS buffer. The .csv files submitted to the FTP are subjected to an auto-check function and renamed according to their status (“*successful*” or “*failure*”). An auto-email function will generate an e-mail to specified individuals if a failure occurs. Any file that fails the auto-check will not load into the SONRIS buffer.

### **3.1.6.3 Floating Mat Data**

All files associated with the floating mat dataset (See Section 3.1.5.3) except for the .csv file will be provided to the CPRA through the *crms-contractor-information* on “*dnr-www2\wetlands\coastres*” FTP site. This includes:

1. the raw data file (.txt)
2. the processed “data processing workbook” file (.xls)
3. the calibration sheet (.xls)

The .csv data file and the .csv calibration file will be provided to the CPRA through the *crms* on “*dnr-www2\ftp\users*” FTP site to be automatically loaded as a matched file-pair into the SONRIS buffer. The .csv files submitted to the FTP are subjected to an auto-check function and renamed according to their status (“*successful*” or “*failure*”). An auto-email function will generate an e-mail to specified individuals if a failure occurs. Any file that fails the auto-check will not load into the SONRIS buffer.

## **3.2. Discrete Data Collection**

Discrete samples include hydrographic or soil porewater readings that are collected at the same location on a monthly basis (or each time an associated continuous recorder is serviced). These water quality readings are taken with a portable, hand-held instrument (e.g., YSI 30 or equivalent) that provides the user with water temperature (°C), specific conductance (µS/cm), and salinity (ppt) readings. When sampling the water column, water level may also be determined by adding a weight near the sensor and graduating the cord. Depth is then measured by gently lowering the cord to the subsurface, assuring that the cord is perpendicular. Discrete hydrographic sampling locations are utilized in many CPRA projects to indicate a spatial and temporal variation in salinity throughout the area over time. Over time the analysis of these readings coupled with the continuous recorder data provides a measure of status and trends with respect to the movement of salinity within an area.

Discrete soil porewater sampling is utilized at each CRMS station. Field personnel will measure soil porewater salinity in each CRMS site at 10 cm (3.94 in) and 30 cm (11.81 in) depths (Sprecher 2000, Bohn 2001), whenever the continuous recorder is deployed or serviced and in at least five (up to ten) vegetation stations during emergent vegetation sampling. Soil porewater constituents are relatively uniform above 20–25 cm (Feijtel et al. 1988), and the sampling depths represent the approximate mean and maximum depth of the root zone (Mitsch and Gosselink 1993).

### **3.2.1 Calibration**

In order to achieve quality data, the CPRA has developed extensive protocols with respect to instrument calibration, field sampling methods, and instrument quality



assurance. Before readings are taken in the field with a hand-held water quality meter, the meter must be calibrated for quality assurance. Because the meter is capable of measuring a wide range of salinity concentrations, the instrument shall be calibrated with a solution that is relatively close to the conditions in the field. The instrument must also be calibrated whenever field conditions have dramatically changed during the sampling trip.

Use the following procedures to calibrate the instrument before taking discrete readings in the field:

- a. Make sure that the conductivity probe is clean and free from any organic or mineral sediment.
- b. Rinse the probe with conductivity-free water, preferably deionized water, between changes of calibration solutions. Conductivity standards must be purchased from an approved manufacturer. Once the standard is removed from its original container, it shall be discarded after its use since the standard is then considered contaminated.
- c. Calibrate the instrument using a conductivity standard most similar to the range of the field samples. The concentration of the standard used for the calibration should be based on the testing needs for the field activity. A single point check standard in the range of the sample concentration to be measured shall be used for field screening and shall be within  $\pm 5\%$  range of accuracy of true value for the calibration to be acceptable.

Note: It is important that the calibration process established by the instrument manufacturer be examined in order to determine suggested concentrations of the conductivity standards for the operating environment encountered at the time of field sampling.

- d. Using the manufacturer's recommended container for calibration, transfer the appropriate amount of solution to the container.
- e. Suspend the probe in the solution so that the electrode does not rest against the container. Make sure the electrode's vent hole is submerged. If necessary, move the probe vigorously from side to side to free the vent hole of air bubbles.
- f. Calibrate the instrument by following the manufacturer's manual for calibration.
- g. Document the concentration of the standard used on the *Discrete Hydrographic/Soil Porewater Data Sheet* (Figure 3.21).

Every hand-held salinity meter shall also be tested and calibrated monthly using the following protocol, and the *Monthly Hand-held Salinity Meter Calibration Data Sheet* (Figure 3.22) shall be completed.

1. Obtain a thermometer that has been manufactured to the standards set by the American Society for Testing and Materials. This thermometer should have the following minimum capabilities: range of 0 °C to 100 °C and divisions of 0.1 °C.

### 3. Hydrologic Data

<b>Discrete Hydrographic / Soil Porewater Data Sheet</b>											
Date _____					Project _____				Sheet ____ of ____		
Instrument _____					Serial Number _____				Calibration Solution _____		
Personnel _____								Agency/Company _____			
Station	CST Time (24 hr)	Staff Gauge (ft)	Depth (ft)	Surface Water			Soil Porewater			NOTES	
				Temp (°C)	Sp. Cond. (µS/cm)	Salinity (ppt)	Temp (°C)	Sp. Cond. (µS/cm)	Salinity (ppt)		
				Bottom / 30 cm							
				Surface / 10 cm							
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**Figure 3.21.** Discrete hydrographic/soil porewater data sheet.

## Monthly Hand-held Salinity Meter Calibration Data Sheet

[illegible]

\* If the instrument is dirty, it should be indicated and then it should be cleaned to prevent any damages.

# If cuts are found on the cable, then the instrument needs to be sent in for repairs unless the cuts do not penetrate the exterior coating.

**Figure 3.22.** Monthly hand-held salinity meter calibration data sheet.

2. Pour a generous amount of a known calibration solution into a container that has been rinsed with the calibration solution. Note: Do not pour this solution back into the bottle.
3. Place the thermometer into the solution and set it aside for a few minutes. This allows the solution to reach room temperature and allows the thermometer to become acclimated to the solution.
4. Take this time to examine the salinity meter. Check for cuts on the wire and for sufficient battery life. Determine whether the instrument is clean, the keypad is working properly, and the LED screen is readable.
5. On the data sheet, record the temperature from the thermometer. Place the probe into the solution and record the temperature, specific conductance, and salinity once the readings have stabilized.
6. If the specific conductance reading is off, calibrate the instrument to ensure it is working correctly and maintaining the calibration.
7. Complete the data sheet with the required information.
8. If the temperature difference between the thermometer and the salinity meter is greater than 1 °C, then the instrument should be sent in for inspection unless the instrument has the capability of adjusting the temperature.

#### **3.2.2 Methods for Discrete Data Collection**

##### **3.2.2.1 *Surface Water Data Collection***

The following methods should be used to collect discrete readings in the surface water environment:

1. Complete the top section of the *Discrete Hydrographic/Soil Porewater Data Sheet* (Figure 3.21).
2. Upon arrival at the station, document the station number and time in Central Standard Time (CST) using the 24-hour military code for this reading. Record the staff gauge reading, if available.
3. Gently lower the probe into the water until it rests on the subsurface, and record the water depth (ft) on the field data sheet. A weight may be fastened to the cable near the probe to ensure the probe remains at the proper depth during sampling.  
Note: If the instrument does not have a water depth sensor, use the following procedure. Before using the instrument in the field, use a calibrated measuring device and place a piece of waterproof tape at 1-ft increments along the cable. Make sure to begin from the tip of the probe and continue the length of the cable. Gently drop the probe into the water until it touches the bottom. Measure the water's depth with the aid of the calibrated tape marks along the cable and record the depth on the data sheet to within approximately 0.3 m (0.5 ft) accuracy. Pull the probe completely out of the water and rinse it free of organic matter before continuing with data collection.
4. Gently drop the probe until it is suspended in the bottom 20% of the water column. Do not allow the probe to rest on the bottom. Record the bottom

readings for temperature (°C), specific conductance (µS/cm), and salinity (ppt) in the *Surface Water* column of the field data sheet. Pull the probe completely out of the water.

5. Gently drop the probe until it is suspended within the top 20% of the water column. Record the top readings for temperature (°C), specific conductance (µS/cm), and salinity (ppt). Note: If the water depth is ≤ 1.5 ft, only one reading will be taken and recorded as both surface and bottom readings.

**ADDITIONAL QUALITY CONTROL READINGS:**

1. The discrete reading instrument shall remain powered if data are being collected all day with the instrument.
2. With the conductivity meter, a minimum of three post-calibration readings (multiple readings) shall be collected from the surface and recorded on the field data sheet. This should occur at the beginning of each sampling day, and when the field team has collected data at multiple stations during the day.

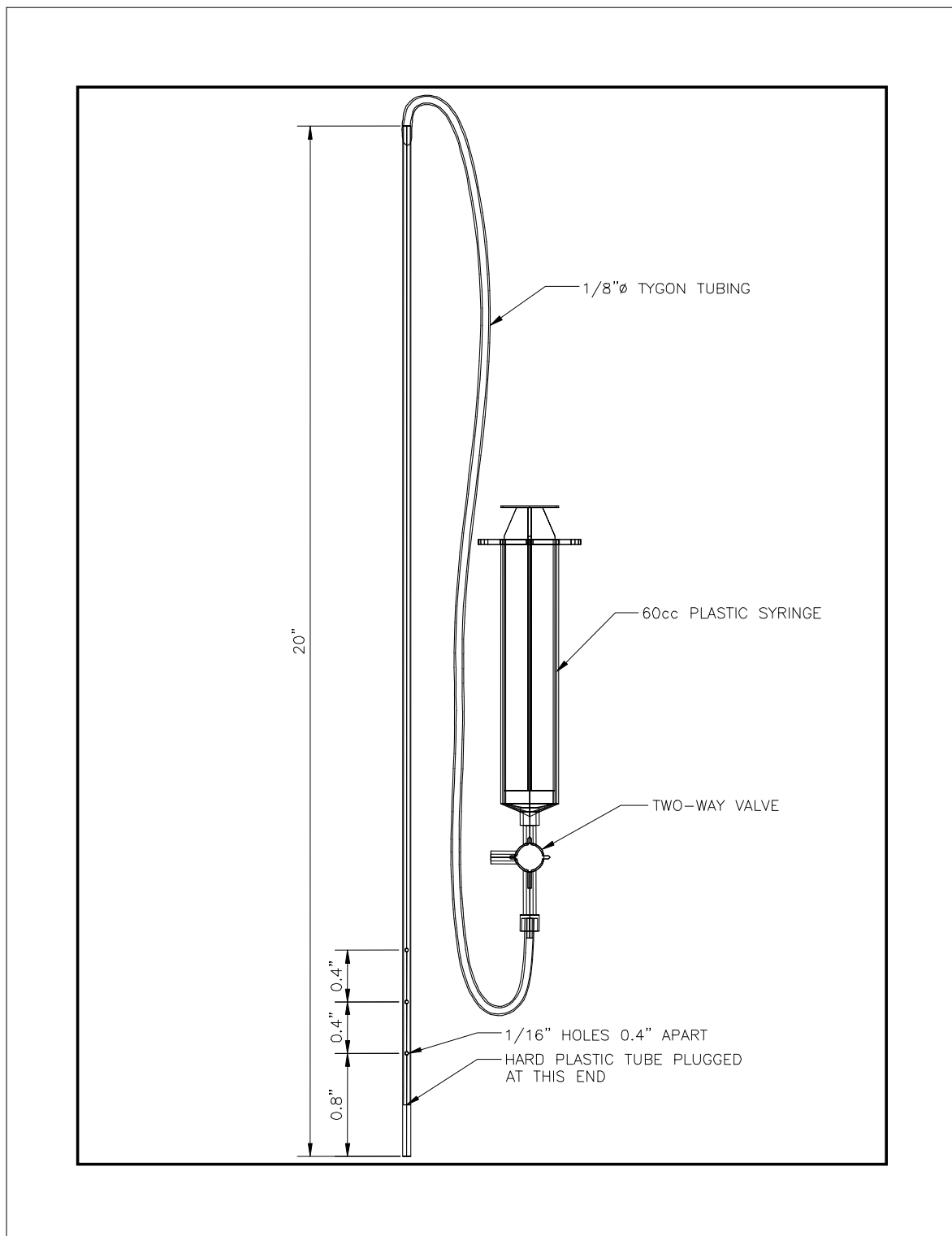
### **3.2.2.2 Soil Porewater Data Collection**

The sipper probe (Figure 3.23) method will be utilized for the monthly sampling of soil porewater and during emergent vegetation sampling at all CRMS sites. Soil porewater salinities can be sampled in the field using a sipper probe to extract interstitial water from 10-cm and 30-cm depths and measured with a hand-held salinity meter (McKee et al. 1988).

**POREWATER SIPPER ASSEMBLY PROCEDURE:**

*Porewater Sipper Materials:*

1. Rigid sipper probes:
  - a. Rigid plastic or stainless steel tubing with a diameter of 3.0 mm (0.12 in.) with a maximum length of 95 cm (37.4 in.)
  - b. Epoxy or sealant
  - c. Drill and bit (1/16")
2. 60-ml syringe
3. 50-ml plastic centrifuge tube (or similar tube) with an inside diameter of at least 2.54 cm (1.0 in.) or large enough for the salinity meter probe
4. Hand-held discrete salinity meter (YSI 30 or equivalent)
5. Tygon® tubing: 30–90 cm (1.0–3.0 ft) length of Tygon® tubing attached to the open end of the rigid sipper probe
6. Two-way valve (if necessary)
7. Cheesecloth (if necessary)



**Figure 3.23.** Typical soil porewater sipper.

*Construction of Porewater Sipper:*

1. Cut the rigid plastic or stainless steel tubing to length (~50 cm).
  2. Seal one end of the tubing with an epoxy or sealant to prevent the passage of any liquid material.
  3. Drill three (3) 1/16" holes, at ninety-degree (90°) angles to each other around the probe, 2, 3, and 4 cm from the sealed end.
  4. Mark 10 cm and 30 cm on the rigid plastic tube measured from the center of the middle holes. Mark using tape or score the tube so that the correct depth can be felt upon insertion.
  5. Securely attach a piece of the Tygon® tubing to the other end of the probe.
  6. Attach a two-way valve to the syringe and to the other end of the Tygon® tubing.
- Figure 3.23 shows the completed porewater extractor and syringe schematic.

At each CRMS site, porewater data will be collected at two depths (10 cm and 30 cm) at all three stations, 1 ft from each tooth and directly between the teeth, along the designated portion of the boardwalk as shown in Figures 2.7 and 2.8). Station numbers shall begin with the sample closest to the access point. For the vegetation stations, only one sample at 10 cm and 30 cm shall be acquired from the vegetation stations. Field personnel will be required to avoid stepping into the vegetation plot. Instead, they shall reach into the plot and carefully but firmly push the porewater sipper to the required depth.

The following procedure shall be utilized to properly collect soil porewater salinity at 10 cm and 30 cm below the surface:

1. Using the *Discrete Hydrographic/Soil Porewater Data Sheet* (Figure 3.21), complete the top section.
2. Prior to each sample, inspect the sipper holes for blockage and unclog as necessary.
3. From the boardwalk in the designated area, or from the outside of the vegetation plot reaching toward the center, insert the porewater sipper into the soil to the 10-cm mark.
4. Before measuring porewater salinity, rinse the tubing, syringe, and centrifuge tube with porewater from each sampling depth at least once. Slowly fill about one-third to one-half the volume (~20–30 ml) of the syringe with porewater and rinse the interior of the syringe thoroughly. Discard the water. Extract another 30 ml of porewater and use it to rinse the centrifuge tube (the use of a two-way valve to dispense water from the syringe into the centrifuge tube is recommended to prevent losing suction on the sipper or the sipper hose).
5. In some cases, there may not be enough water in the marsh soil for rinsing. Instead, deionized water may be used.
6. Dispose of the rinse and pull a third aliquot of porewater—enough to fill the centrifuge tube and cover the probe when it is in the centrifuge tube (~30–45 ml). In highly organic soils, porewater extraction may be blocked or severely inhibited by organic or small clay particles. If this condition occurs, securely fasten a piece

- of cheesecloth around the intake holes of the porewater sipper(s) to filter obstructing particles and extract another sample.
7. Dispense the sample into the centrifuge tube using the two-way valve and insert the salinity probe. Try to keep the probe from touching the side of the centrifuge tube. Record the station ID, date (MM/DD/YYYY), time (CST), temperature (°C), specific conductance ( $\mu\text{S}/\text{cm}$ ), and salinity (ppt) in the *Soil Porewater* column of the field data sheet (Figure 3.21) for each porewater sample.
  8. Carefully push the sipper to the 30-cm graduation mark. Repeat steps 3–5.
  9. Remove the sipper probe and move to the next station. Repeat steps 1–6 for each station.
  10. If a porewater sample cannot be collected, make notes explaining why on the datasheet in the comments.

### 3.2.3 Discrete Data Processing and QA/QC

The CPRA has implemented a two-phase protocol for data processing of discrete surface water and porewater data. These two phases are referred to as data entry (Phase I) and data quality assurance/quality control (Phase II). These two phases are conducted by separate individuals to assure that the final product is in 100% agreement with the data collected during the field sampling procedure.

**DATA ENTRY (PHASE I):** Phase I is conducted by the individual responsible for the field data collection and requires three main tasks: 1. field data sheet review, 2. data transcription, and 3. data verification. These tasks require specific procedures necessary to satisfy the deliverable requirements. Below are the procedures for each task.

1. Field Data Sheet Review
  - a. Review the data sheet for legibility, completeness, and accuracy.
  - b. Make corrections using a different color pen without erasing original data. If an error needs to be corrected: strike a single line through the error, and write the changes close to the error.
  - c. Accompany changes with the responsible person's initials and date.
2. Data Transcription
  - a. This task requires the photocopied field data sheet and the "Discrete Hydrographic and Soil Porewater\_Autoload Template\_08092005.xls" file located on the CPRA FTP site. This file contains one worksheet with just the headers (Figure 3.24).
  - b. Once the Excel file has been located and saved to a local computer, the file shall be saved using the following naming convention:  
Surface water: "*Discrete\_YYYY-MM.xls*."

Soil porewater: “CRMSXXXX\_PW\_YYYY-MM.xls,” i.e.,  
“CRMS0398\_PW\_2008-04.xls.”

- c. Enter recently collected data verbatim into the worksheet beginning in row 2 in the appropriate columns. Surface water data from multiple project areas and stations collected during the same month may be entered into the same worksheet. However, there should be a soil porewater data file for each CRMS site per sampling month.

#### 3. Data Verification

- a. Upon completion of steps 1 and 2, double-check the file for accuracy.
- b. Upon completion of the review of data, provide the field data sheet along with the electronic files to the QA/QC officer. This should be part of the packet for the continuous recorder data also.

**QUALITY ASSURANCE/QUALITY CONTROL (PHASE II):** Phase II begins when the QA/QC officer is provided the field data sheet and is notified that the Excel file has been completed. The QA/QC officer should follow the steps below to ensure the data has been processed properly:

1. Examine the field data sheet for completeness and errors.
2. Check the data from the field data sheet to ensure it was correctly entered into the Excel file.
3. If mistakes are found, return to the data collector so any mistakes can be corrected or explained.
4. Continue this process until no mistakes are found.

A recommended QA/QC Checklist template is found in Figure 3.19 and is also available as an Excel file (Hydrologic QAQC Checklist Form template 03022005.xls). However, printing and completing the QA/QC Checklist is not a requirement nor is it a deliverable.

Once Phases I and II have been completed, open the .xls file “*Discrete\_YYYY-MM.xls*” or “*CRMSXXXX\_PW\_YYYY-MM.xls*” and save as a .csv file using the same name to be uploaded to CPRA’s FTP site. The data sheet will be scanned and saved as a PDF using the naming convention “*Discrete\_YYYY-MM.pdf*” or “*CRMSXXXX\_PW\_YYYY-MM.pdf*.”



### 3. Hydrologic Data

Station ID	Date (mm/dd/yyyy)	Time (hh:mm)	Staff Gauge (ft)	Depth (ft)	Bottom Water Temperature (°C)	Surface Water Temperature (°C)	Bottom Specific Conductance (uS/cm)	Surface Specific Conductance (uS/cm)	Bottom Salinity (ppt)	Surface Salinity (ppt)	Bottom Dissolved Oxygen (milligrams/L)	Surface Dissolved Oxygen (milligrams/L)
BS03A-06R	01/23/3001	14:21		2	10.7	11	3520	3631	1.9	1.9		
BS03A-06R	02/22/3001	11:33		1	22.8	23.5	3704	3705	1.9	2		
BS03A-06R	03/22/3001	11:15		2.5	15.6	17.6	395	392	0.2	0.2		
BS03A-06R	04/27/3001	07:54		1.5	21.5	21.7	1950	1929	1	1		
BS03A-06R	05/29/3001	09:19		0.5	31	31	1972	1972	1	1		
BS03A-06R	06/26/3001	11:17		2	26.8	29.6	1245	1205	0.6	0.6		
BS03A-06R	07/27/3001	08:54		2.5	26.5	28.2	1020	835	0.6	0.4		

(continued...)

Bottom pH (pH units)	Surface pH (pH units)	Bottom Velocity (ft/sec)	Surface Velocity (ft/sec)	Secchi (ft)	Fecal Coliform (MPN/100ml)	Soil Porewater Temperature at 30 cm (°C)	Soil Porewater Temperature at 10 cm (°C)	Soil Porewater Specific Conductance at 30 cm (uS/cm)	Soil Porewater Specific Conductance at 10 cm (uS/cm)	Soil Porewater Salinity at 30cm (ppt)	Soil Porewater Salinity at 10cm (ppt)	Organization Name
												Coastal Test Inc
												Coastal Test Inc
												Coastal Test Inc
												Coastal Test Inc
												Coastal Test Inc
												Coastal Test Inc
												Coastal Test Inc

**Figure 3.24.** Discrete hydrographic autoload template.

#### **3.2.4 Discrete Data Deliverables**

The following deliverables will be provided to the CPRA for discrete data collection:

1. The data sheet (.pdf) will be provided through the *crms-contractor-information* on “*dnr-www2\wetlands\coastres*” FTP site.
2. The processed data file (.csv) will be provided through the *crms* on “*dnr-www2\ftp\users*” FTP site to be auto-loaded into the SONRIS database buffer.

Once the CPRA has accepted the data in electronic format, the original data sheets will be delivered to the CPRA.

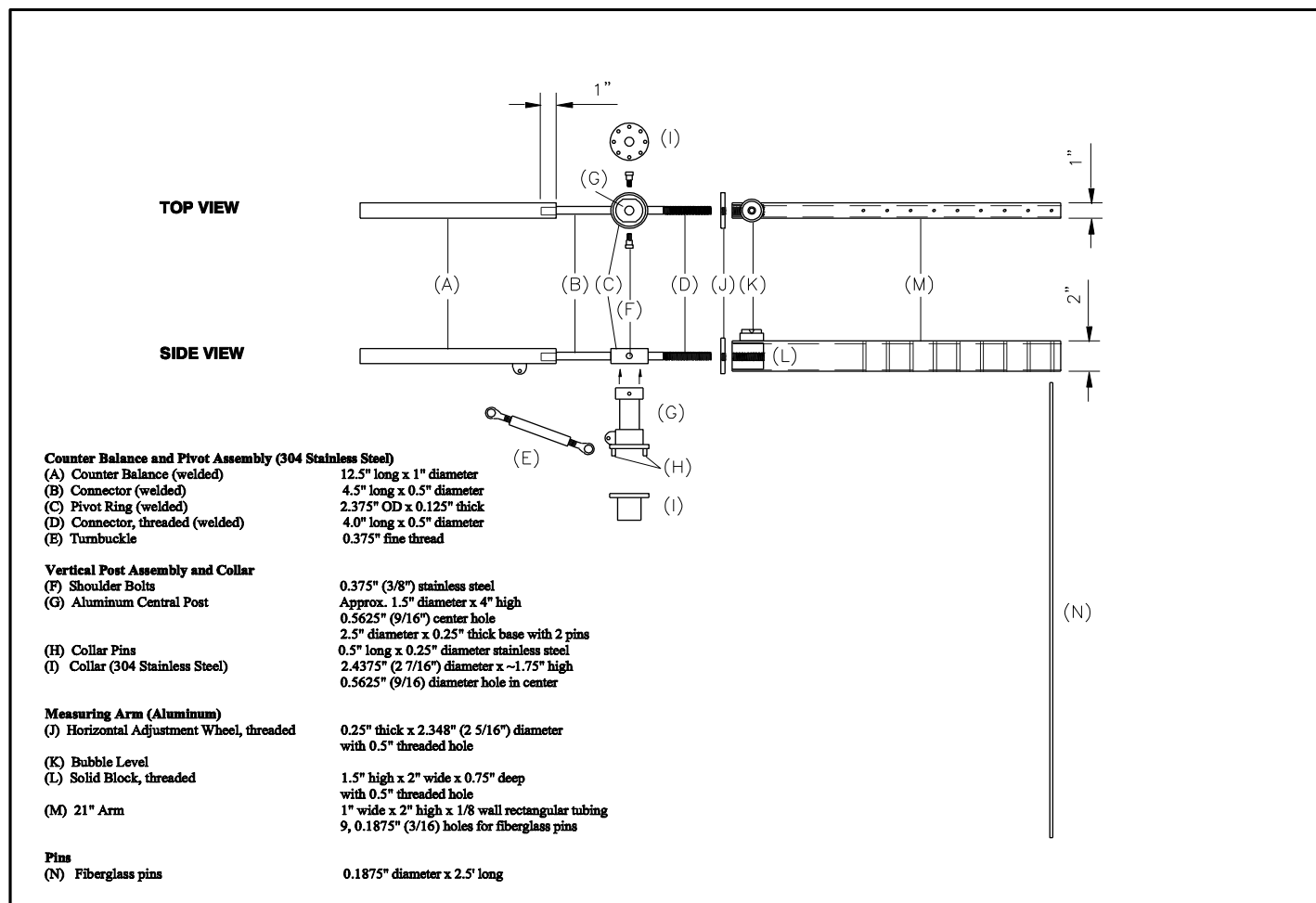
## 4. ROD-SURFACE ELEVATION TABLE

The CPRA has implemented the use of the rod-surface elevation table (RSET) technique that has been developed by Cahoon et al. (2002a) and Cahoon et al. (2002b). The RSET is the preferred version of the surface elevation table (SET) that has been established at specified locations in attached, herbaceous marsh and swamp/bottomland hardwood forest ecosystems. The RSET method provides a non-destructive process that precisely measures changes in sediment elevation over time relative to a fixed subsurface datum. Briefly, a series of 4-ft stainless steel benchmark rods are driven through the root zone, the organic matter, and any soft underlying materials until refusal is encountered by a driving force on the rod. The rod remains approximately 2 ft above the marsh surface and is stabilized by a 6-in diameter pipe that is cemented at the surface. A custom-made stainless steel collar (Figure 4.1, part “I”) is permanently attached to the rod to provide a constant horizontal reference plane for long-term repeatability as the table remains fixed for each sampling period.

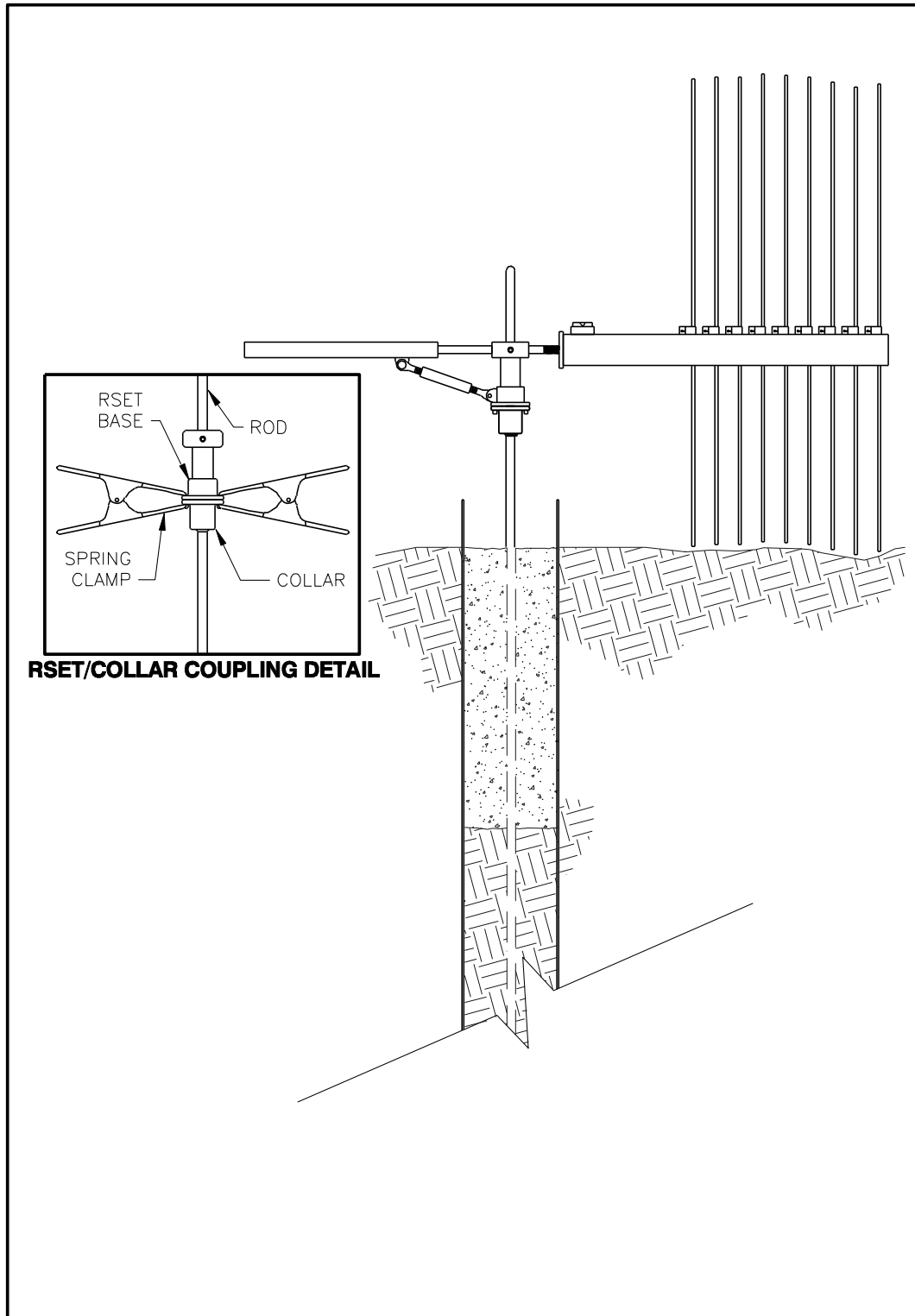
Data collection occurs by attaching a custom-made RSET table (Figure 4.1) to the collar and lowering nine fiberglass pins through the table to the marsh surface (Figure 4.2). The height (measured in millimeters) that each pin extends above the table is used to calculate vertical changes of the marsh surface over time. The table is repositioned to measure the marsh surface at four 90° angles, providing 36 measurements per station. Using previously collected data, the rate of change can be calculated to provide a measure of status and trends with respect to changes occurring between the surface and the bottom of the stainless steel rod.

The RSET table is custom made and constructed of aluminum and stainless steel. The CPRA will supply surface elevation tables and components necessary to acquire repeatable, precise, and accurate measurements.

Marsh surface elevation change measured with the RSET is influenced by both subsurface processes occurring in the soil profile and surface accretion, whereas the feldspar marker horizon (Section 5, Vertical Accretion) measures only surface accretion. When these two techniques are used in conjunction, they can provide information on below ground processes that influence surface elevation change. Differences between the rates of vertical accretion and surface change can be attributed to processes occurring below the feldspar layer and above the bottom of the RSET benchmark pipe. Consequently, it is imperative that the first RSET measurement occurs on the same day as the establishment of the accretion plots, and subsequent RSET measurements occur on the same day accretion data is collected. The accretion plots are established using the feldspar marker horizon method described in Section 5. The information derived from these two methods does not account for any process that occurs beneath the depth of the rod.



**Figure 4.1.** Construction drawing of a surface elevation table used on a 9/16" benchmark rod (Source: Cahoon et al. 2002b).



**Figure 4.2.** A typical RSET data collection schematic showing nine pins used to measure marsh surface elevation.

## 4.1 Field Station Establishment

Upon completion of the boardwalks, the deep rod needed for the RSET was established from the boardwalks at existing CRMS sites and will be established at new CRMS sites. When installing new sites, it is imperative that the installation of the rod for the RSET be performed without disturbing the area. The rod for the RSET will be established using the guidelines set forth in Cahoon et al. (2002) which describes the design of the RSET that will be supplied by the CPRA and the rod benchmarks that can be used with the RSET.

The CPRA will provide the collar to permanently attach to the rod during the installation phase. The CPRA will also provide the RSET and the necessary components needed to collect the measurements. Figure 4.2 shows a schematic of the benchmark with the collar.

### *Deep Rod Benchmark Materials:*

1. Multiple 9/16" diameter by 4-ft stainless steel rods with threads (Berntsen SS91604 or equivalent)
2. 9/16" diameter stainless steel drive point (Berntsen SS12 or equivalent)
3. Locking connector thread (Berntsen M13 or equivalent)
4. Steel drive pin for a 9/16" diameter rod (Berntsen M1DPA or equivalent)
5. Power driving adapter (Berntsen PDA or equivalent)
6. Loctite® cement for stainless steel
7. PVC, Schedule 40, 6" diameter by 3–4 ft
8. Cement mix
9. Collar and screws (Figure 4.3, in RSET; provided by CPRA)

### *Installation Materials:*

1. Power driving device (Pionjar 120, Cobra 148, or equivalent)
2. Pipe wrenches (two 6" wrenches)
3. Post-hole digger (maximum 6" diameter)
4. Hacksaw
5. File
6. 2" x 12" x 10-ft treated board (2)
7. Cement mixing equipment: bucket, shovel, water, etc.
8. protective equipment (minimum eye protection, gloves, and ear plugs)
9. Hammer or small sledgehammer
10. Bucket to remove the soil

*Deep Rod Benchmark Installation Procedure:*

1. Place the board(s) across the two existing boardwalks where the rod for the RSET will be installed. If more than one person will be installing the rod for the RSET, a second board shall be used for safety.
2. Using a post-hole digger, dig a hole 1½–2 ft deep with a maximum diameter of 6 in. in the center between the two boardwalks and the center of the 10-ft boardwalk. Note: All soil or surface material extracted from the hole shall be placed in a bucket and not on the marsh/swamp surface. Upon completion, the extracted material must be discarded outside of the 200 x 200-m site. No soil or extracted material shall remain on the surface.
3. Drive the 9/16" stainless steel rods in the center of the hole to refusal using the manufacture's recommended procedures for the rods. These procedures shall include the use of all the materials listed in the benchmark materials list. Note: Refusal is defined as "No more than 1 foot of penetration of the rod in one minute of impacting with a gasoline powered reciprocating driver (i.e., Pionjar 120, Cobra 148, or equivalent)." The rod must also be plumb at the end of the installation.
4. The rod shall remain 2 ft above the marsh surface after the rod is driven to refusal. Any excess shall be cut with a hacksaw.
5. Position the 6" PVC such that the 9/16" stainless steel rod is at the center. Push the PVC pipe into the soil until 2–4" remain above the surface. A small hammer may be used, depending on the soil characteristics.
6. Mix enough concrete to fill the PVC. Note: When mixing the concrete and or filling the PVC, no concrete shall remain on the sediment surface outside the PVC.
7. Fill the PVC. Be sure not to overflow the PVC.
8. Slide the collar 8" below the top of the stainless steel rod.
9. Position four of the eight holes on the collar to point toward the four corners of the surrounding boardwalk.
10. Attach the collar in position so that the Collar IDs stamped on the collar are oriented toward the corner of the RSET plot using the four screws and Loctite® cement. Be sure not to move the rod when fastening the collar to the rod if the cement is still wet.
11. The final product shall resemble Figure 4.3.

The RSET will be established at sites approved by the CPRA. In areas where the marsh is classified as floating, a rod for the RSET will not be established. Instead, a deep rod monument will be established in a close proximity to the site. The establishment of this secondary monument will follow "A Contractor's Guide to Minimum Standards" (CPRA 2011), unless a more recent version is released.

Documentation shall be made of the depth of refusal and the distance from the top of the rod to the top of the collar at each site and shall include the number of rods used during the installation as well as a length in feet. Pictures shall contain a date stamp. These pictures will ensure the CPRA that the surface adjacent to the monument was not disturbed.

When establishing the elevation of the rod for the RSET using RTK surveying methods, no equipment shall touch the surface between or within a 10-m (32.8-ft) buffer zone around the boardwalk. Since this area is being used for the collection of scientific data, any instrumentation or equipment that is placed on the marsh/swamp surface may compromise the data collection efforts. Consequently, all the equipment that is used to determine the elevation of the benchmark must be raised using a technique that meets the requirements of the surveyor and meets approval from the CPRA.

### 4.2 Data Collection

The CPRA shall provide all the necessary components needed for the RSET data collection. To assure that the highest degree of precision is achieved, it is imperative that all the components of an individual unit remain together. Since the CPRA will provide multiple units, each one will possess a unique serial number. Therefore, when a piece breaks or problems arise with the equipment, the CPRA must be informed immediately because this equipment is manufactured through the specifications developed by this agency.

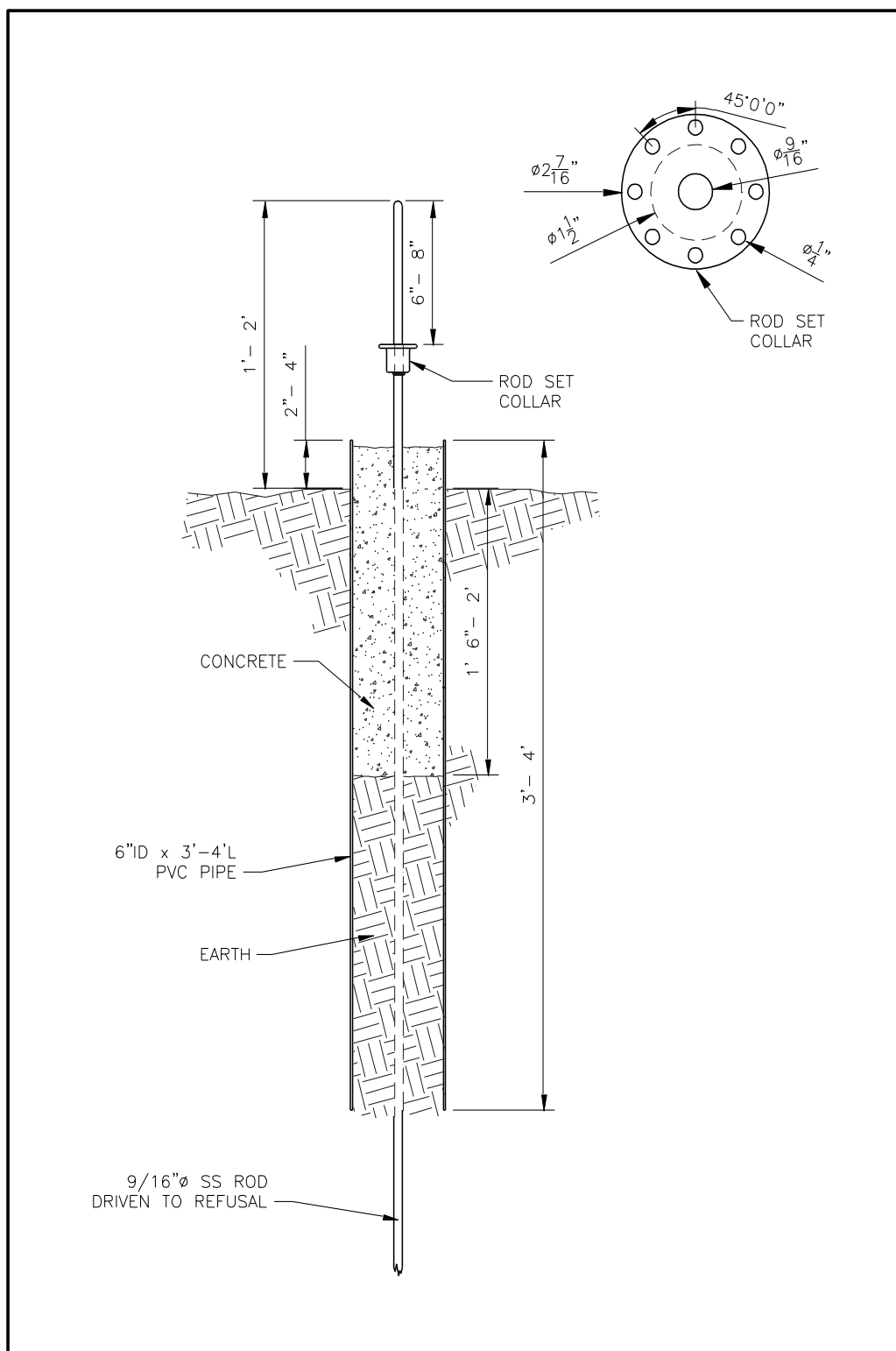
Each RSET unit shall contain the following components (minimum):

1. The surface elevation table
2. Minimum of nine (9) fiberglass rods (numbered to correspond with numbered holes on table, respectively)
3. Minimum of nine (9) badge clips
4. Minimum of two (2) spring clamps
5. Aluminum metric ruler, capable of measuring in millimeters with the end being zero millimeters

Due to some variability between crucial pieces, it is imperative that the RSET unit being used to take the initial reading at a station be used for all subsequent measurements. Therefore, the unit used for the initial reading shall be documented on the “Surface Elevation Table (RSET) Data Sheet” (Figure 4.4) to verify that the same unit was used at all subsequent data collections.

The following protocol has been adopted from the sampling method developed by Cahoon et al. (2002a, b). The sampling protocol is also thoroughly explained on Cahoon’s USGS web site <http://www.pwrc.usgs.gov/resshow/cahoon/>. These references give an excellent overview of how the sampling occurs, but note that the following protocol is written for the collection of data according to the CPRA standards.





**Figure 4.3.** Detailed construction drawing of a typical RSET station with collar. Inset: Collar detail.

*Field Materials:*

1. RSET unit (contains the RSET and components listed above)
2. Data sheet(s) (Figure 4.4)
3. Field notebook
4. Pencils
5. One or two 2" x 12" x 10-ft boards
6. Compass
7. Digital camera
8. Cleaning supplies (brushes, towels, WD40®, etc.)

*Procedures:*

Note: Accretion stations will be established on the same day as the first RSET reading and are to be sampled when the RSET measurements are taken. Data from the previous RSET sampling should be downloaded from the database in order to review notes about the surface on which pins were previously placed in order to replicate that sampling effort as much as possible.

Note: No walking on the marsh surface is permitted; all work is performed from the boardwalk. Additionally, RSET personnel must understand present and past site conditions as noted in the hydrologic comments and Operations and Maintenance (O&M) reports produced (or provided by a hydrologic data contractor).

#### 4. Rod-Surface Elevation Table

Surface Elevation Table (RSET) Data Sheet					
Distance from top of rod to collar (mm):			RSET ID:		
Project: _____					
Station: _____		Sample Date: _____		Time: _____	
Organization: _____		Establishment Date: _____		Time: _____	
Measured by: _____		Field personnel: _____			
Pin	Direction (Degrees) (Collar #)	Observed Pin Height (mm)	Omit (X)	Observation Comments (specific notes on pin placement)	
1					
2					
3					
4					
5					
6					
7					
8					
9					
1					
2					
3					
4					
5					
6					
7					
8					
9					
1					
2					
3					
4					
5					
6					
7					
8					
9					
1					
2					
3					
4					
5					
6					
7					
8					
9					
1					
2					
3					
4					
5					
6					
7					
8					
9					
<b>Site Conditions:</b> <b>Water depth:</b> _____ cm / not flooded (wet / dry) <b>Veg.:</b> healthy / senesced / stressed / dead					
<b>Soil Type:</b> organic / mineral (sand / silt / clay) <b>Consistency:</b> very firm / firm / soft / very soft / unconsol.					
<b>Thatch thickness</b> (if any): _____ cm; <b>Pins placed:</b> on top of / beneath <b>Disturbance</b> (if any):					
<b>Dominant spp.</b> _____				<input type="checkbox"/> Human	
<b>Other:</b> _____				<input type="checkbox"/> Grazed	
				<input type="checkbox"/> Burned	
				<input type="checkbox"/> Animal tracks/nest	

**Figure 4.4.** Surface elevation table (RSET) data sheet.

Swamp Site Note: If the site is flooded and the soils are flocculent and/or have floating marsh at the surface, no data collection for RSET or accretion cores shall take place on that trip. Be prepared to read the RSET and take accretion cores in the future when water levels are low enough to do so (with no flocculent soils and mat not floating). The problem is that the surface to which the accretion measurement is made (from the feldspar to the top of the soil frozen in the core) is meant to be the same surface on which RSET pins are placed. In highly flocculent soils with multiple potential RSET surfaces, making measurements on the same surface is impossible or would only reflect water level, not soil level in floating marsh systems. CPRA maintains a list of stations where elevation change measurements have been suspended or eliminated.

Sample Collection:

1. Place one or two boards between the boardwalks.
2. Move any material that has grown or accumulated on the stainless steel rod and collar. The table must sit flush on the collar.
3. Verify that the collar has not moved vertically or around the rod.
  - a. Using a metric ruler, measure the distance between the collar and the top of the stainless steel rod in millimeters. Record the distance in the appropriate place on the data sheet.
  - b. Slide the RSET onto the rod, and align the collar pins (Figure 4.1, part "H") with the holes in the collar such that the table points in the number 1 direction on the collar. Secure the RSET using the clamps.
  - c. Check the bearing of the table direction to determine whether or not the collar has rotated around the rod.
  - d. If the collar has moved, continue to step 4. If the collar has not moved, proceed to step 5.
4. Document that the collar has moved and note any other obvious damage that would prevent a direction from being used. Report the damage to CPRA, document with pictures and detailed comments, and re-tighten the collar.
  - a. Re-tighten the collar as close as possible to the original height and position (bearing). Apply Loctite® to the threads of the four screws and make sure the collar is secure.
  - b. The RSET instrument should be leveled after the collar is re-tightened and the Loctite® is dry. The data from the first reading after adjusting the collar will be considered a new baseline. The station establishment date and time should be the date of collar maintenance from that point forward.
5. Fill out the top of the data sheet including: the collar to top of rod measurement obtained in step 3 or 4, RSET ID number stamped on the instrument, project name (CRMS), group (if one is provided by CPRA), station ID, sampling date and time, data collection organization's name, establishment date and time, the name of the person reading the measurements, and the names of other field personnel on the trip.

Note: Establishment date refers to the date the first reading was taken in

- a direction. If a direction is compromised and a new direction is used, or if the collar is reset; then a new establishment date shall be used.
6. Slide the RSET (Figure 4.1) onto the rod, aligning the collar pins (Figure 4.1, part “H”) with the holes in the collar such that the table points in the direction of one of the four corners of the boardwalk. Note: Sampling will occur at four (4) 90° angles.
  7. Clamp the RSET to the collar using two spring clamps.
  8. Level the RSET vertically and horizontally using the level bubble and lock it into place with the turnbuckle. The RSET should perfectly level in order to get precise measurements. If the table is bumped during data acquisition, re-level it.
  9. Record the compass bearing next to the corresponding collar ID direction on the “Surface Elevation Table (RSET) Data Sheet” (Figure 4.4).
  10. One at a time, place the nine (9) fiberglass pins (3/16”) in their corresponding numbered holes on the arm of the RSET and secure them with badge clips so that the pins are just below the bottom of the RSET arm.
  11. Gently lower the pins onto the surface of the marsh and secure with badge clips.

Note 1: It is easiest to lower pins in order of farthest from the reader to closest to the reader. Unclip badge clips before lowering pins instead of pulling against the clip so as not to make indentions in the surface with already-placed pins.

Note 2: There are multiple potential marsh surfaces. Each RSET reader tends to interpret the surface differently from other readers, so it is best that the same person read the RSET at a given site. If this is not possible, the fact that there are different readers should be noted under “Site Conditions.” Careful notes should be recorded each time RSET data is collected regarding the surface on which pins are placed and actions that occurred to get the pins to that surface (moving stems or unattached leaves). An effort should be made each time RSET data is collected to interpret the surface the same way it was previously interpreted. These notes can be placed in the “Site Conditions” section at the bottom of the data sheet.

Note 3: In practice in the field, accretion and RSET measurements should be taken at the same time and the two persons collecting the data should communicate while deciding how to define the surface. After the first cryo-core is taken and while pins are being placed in the first RSET direction, the RSET and accretion measurers should make sure both persons understand and can identify the surface being measured to. For example, if the person reading the RSET would define the surface as a more consolidated layer just beneath a watery slurry, the accretion measurer should make sure he/she could distinguish that surface in the cryo-core. The muddy slurry may look the same as the consolidated surface when frozen. In that case, the RSET reader would need to level pins to the muddy slurry. Or, as a second example, if the person reading the RSET would prefer to work pins through a thick layer of unconsolidated thatch down to a more consolidated organic

surface, the accretion reader should make sure he/she can distinguish the thatch from the more consolidated organic layer. If the thatch looks the same as the organic surface in the cryo-core, the RSET reader would need to level to the top of the thatch.

12. Measure from the top of the RSET arm (Figure 4.1, part “M”) to the top of the pin and record the distance in millimeters on the data sheet in the “Observed Pin Height (mm)” field. The measurer should make sure his/her eyes are level with the top of the pin to avoid parallax. Note: The person recording the measurements should verbally repeat the measurement back to the measurer to assure that the correct number was understood and recorded.
13. As the RSET pins are being placed on the surface and measurements are being taken, the measurer should make specific comments about the surface that individual pins are resting on if it differs from the other pins in that direction (e.g., “in a crab hole” or “in a culm of *Spartina patens*”). These pin-specific comments go in the “Observation Comments” field on the data sheet.
14. If it is not possible to place pins on the surface and it is the professional opinion of the RSET reader that the pin is on an un-representative surface for that site, record the “Observed Pin Height (mm)” and mark an “X” in the “Omit (X)” field on the data sheet for that pin. All omissions should be accompanied by an Observation Comment. Common reasons for omitting pins include:
  - a. A pin is blocked from reaching the marsh surface by a thick stem or shrub.
  - b. A pin lands in a hole not representative of the marsh type, like a crab burrow or pig track.

Note: Natural depressions and higher elevation areas caused by subsurface roots should be noted but not omitted. In some cases, especially in fresher marsh types, the surface is a net of roots with spaces between them. In those cases, note the surface that the pins fall on but do not omit them if they are truly representative of the surface. Some surfaces are highly variable and the variation is to be expected. In particularly problematic, confusing, or odd sites, photograph the plant-soil interaction. Use as descriptive botanical terms as possible when describing the reason for omitting pins due to interaction with the base of a plant (e.g., aerial roots, rhizome, stem base).
15. After recording measurements, pull each pin about two-thirds of its length up and clip each with a badge clip so that the bottoms of the pins do not interfere with rotating the RSET.
16. Unclamp, lift, and rotate the RSET arm 90° (towards another boardwalk corner).
17. Repeat steps 11 through 16 until four sets of 90° measurements have been obtained.

18. Describe the condition of the RSET plot in the “Site Conditions” box at the bottom of the data sheet. There are prompts in “Site Conditions” for the following data:
  - a. Water depth in the RSET plot (measure in three or more locations and estimate average depth) or a note if the marsh is dry. If the marsh is not flooded, note whether it is wet or dry. Provide additional notes if it is very dry and cracked.
  - b. Vegetative health (healthy, senesced, stressed, dead). Also note dominant vegetation.
  - c. Description of the soil surface composition (organic or mineral) and if mineral, what kind of mineral (sand, silt, clay), if known. Type of mineral soil does not have to be selected. More than one mineral soil type can be selected.
  - d. Disturbance to the RSET plot and the cause of the disturbance, if known (fire, grazing, other animal activity [trails, nests], human, other).
19. Take a digital picture providing an overall view of the RSET plot (above). The picture should be taken from the access boardwalk, facing the RSET plot and short boardwalk. Another picture shall be taken providing a close-up view of the marsh surface (flash on) somewhere within the RSET plot that is representative of the site surface (below). The below picture should include the base of dominant vegetation if present. Other digital pictures should be taken of the marsh surface for all unusual or difficult pins.
20. If a disturbance occurs that would alter a majority of the readings in a particular direction, the table shall be rotated 45° from the initial direction to obtain new readings (to one of the even-numbered collar directions). Establishment of new directions should be well documented and subsequent readings should be taken from this position. The new position will have a new establishment date that differs from the other directions. Human disturbance and large-scale animal disturbances (muskrat mounds, alligator trails) are reasons to move directions. If the disturbance is not human-induced and it affects all possible directions, continue to measure the RSET if possible.

CONVERSION OF STATIONS TO OPEN WATER:

The intent of the CRMS monitoring program is to maintain the original monitoring stations for as long as possible. RSET stations will not be moved to new locations if the original location erodes away. Therefore, every attempt will be made to collect elevation change data during each sampling interval. If longer pins are needed to reach the surface in an eroding environment, the contractor should be prepared with longer pins or should return to a site to re-sample if pins were inadequate. RSET rods are not expected to stand up to wave action in open water for extended periods of time. If the rods become bent and the station is in open water, install a staff gauge at the site and continue to measure bottom surface elevation in the four directions around the original RSET rod location. Database modifications will have to be made to accommodate these staff gauge data. CPRA will advise as needed when these issues arise.

### 4.3 Data Processing

The CPRA has implemented a two-phase protocol for data processing. These two phases are referred to as data entry (Phase I) and data quality assurance/quality control (Phase II). These two phases are conducted by separate individuals to assure that the final product is in 100% agreement with the data collected during the field sampling procedure.

**DATA ENTRY (PHASE I):** Phase I is conducted by the individual responsible for the field data collection (e.g., the measurer) and requires three main tasks: 1. field data sheet review, 2. data transcription, and 3. data verification. These tasks require specific procedures necessary to satisfy the deliverable requirements. Below are the procedures for each task.

1. Field Data Sheet Review
  - a. Review the original data sheet for legibility, completeness, and accuracy.
  - b. Make corrections using a different color pen without erasing original data. If an error needs to be corrected, then the responsible person should strike a single line through the error and write the changes close to the error. Note: The original data should still be legible after corrections are made.
  - c. Accompany changes with the person's initials and date.
2. Data Transcription
  - a. CPRA has developed a data upload tool that allows the user to enter data into a Microsoft Excel spreadsheet that looks like the field data sheet. The Excel file transfers the data from the digital data sheet into a spreadsheet that is formatted for upload to SONRIS. The file, "RSET\_data\_tool.xls" is available on the CPRA FTP site. Alternately, the contractor may elect to develop their own data transcription tool.
  - b. Enter recently collected data into the "1\_RSET Data Sheet," which is formatted to look like the field data sheet.
  - c. When entering pin comments into the "1\_RSET Data Sheet" "Observation Comments" cell, enter specific observations about individual pins first and any general comments on the entire direction last.
    - i. The prompted drop-down boxes in the "Site Conditions" section are the minimum site notes required. Additional comments are usually necessary to help the RSET reader identify the same surface in future RSET sampling.
  - d. Data entered into the "1\_RSET Data Sheet" will automatically populate "2\_ to SONRIS," which may be saved as a .csv file to upload to SONRIS through the CPRA FTP site.
  - e. Save a copy of the RSET data tool to the CPRA FTP site using the following naming convention:  
 "Station\_RSET\_data\_tool\_seasonYEAR.xls", e.g.,



“CRMS0398\_RSET\_data\_tool\_Spring2011.xls.”

- f. Save the digital photos as .jpg files using the following naming convention: “Station\_E01\_Above or below \_seasonYEAR.jpg,” e.g., “CRMS0398\_E01\_Above\_Spring2011.jpg.” “Above” refers to the photo taken of the plot from above. “Below” refers to the photo taken of the marsh surface down in the vegetation, if present.

### 3. Data Verification

- a. Ensure no transcription errors occurred from the field data sheet to the digital data sheet.
- b. Check that the data was automatically populated to “2\_to SONRIS” correctly and in a clear fashion. Check that the “Site Conditions” section merged clearly and that the “RSET measurer” name on the Data Sheet is the first person listed under “Personnel.”
- c. In order to assure highest-quality data collection, make the following checks relative to previously collected RSET data:  
Note: The data from the previous data collection should have been downloaded from SONRIS before sampling occurred to refresh the RSET reader’s memory about decisions made previously concerning the definition of the soil surface at that site. After data collection, the following should be checked against the previous data collection:
  - i. RSET reader is the same person if possible (first name in “Personnel”).
    1. If the RSET reader must change, the discrepancy should be noted in the “Site Conditions” section of the comments.
  - ii. RSET Direction (Collar #) and Direction (Deg) are consistent over time. The bearing (deg) for Collar #s should not change.
  - iii. The same RSET instrument (RSET ID) is consistently being used at a CRMS site.
- d. Upon completion of the review, provide the data along with the field data sheet to the QA/QC officer.

**QUALITY ASSURANCE/QUALITY CONTROL (PHASE II):** Phase II begins when the QA/QC officer is provided the field data sheet and is notified that the digital data sheet is ready. The QA/QC officer should follow the steps below to ensure the data has been processed properly. However, printing and completing the QA/QC Checklist (Figure 4.5) is not a requirement nor is it a deliverable. The digital form of the QA/QC Checklist template is called “RSET QAQC Checklist Form\_template\_ 092607 .xls.”

The QA/QC officer should complete the following procedures:

1. Examine the field data sheet for completeness and errors.
2. Check the data from “1\_RSET Data Sheet” worksheet against the field data sheet (Figure 4.4) to ensure it was correctly entered into the Excel file.
3. Check that the data was automatically populated to “2\_to SONRIS” correctly and in a clear fashion.

4. If mistakes are found, return the field data sheet and Excel file to the data collector so any mistakes can be corrected or explained.
5. Continue this process iteratively until no mistakes are found.
6. Scan a copy of the corrected data sheet into a .pdf file for upload to the CPRA FTP site.

Once Phases I and II have been completed, save the final version of the “2\_to SONRIS” worksheet from the “RSET\_data\_tool.xls” as a .csv file for data upload to CPRA’s FTP site.

#### **4.4 Deliverables**

Electronic files containing the data shall be in the appropriate deliverable format (Figure 4.6) and delivered to CPRA once the data has completed the QA/QC process.

Deliverables should include the following:

1. RSET data file (.csv)
2. RSET original field data sheet (.pdf)
3. RSET data tool (.xls)
4. Photography (.jpg)

## 4. Rod-Surface Elevation Table

RSET QA/QC CHECKLIST		
Project / Site Number: _____ Date RSET data collected: _____ QA officer: _____		
Data Collector: _____ Date of last RSET data collection: _____ Date approved: _____		
DNR/USGS QA Officer: _____ Date: _____		
		QA Officer's Initials and Date
1	Was a field trip report generated ? <b>Y / N</b> COMMENTS:	
2	Were all data entered in datasheets correctly (i.e., data entered in correct columns, all data in correct units)? <b>Y / N</b> COMMENTS:	
3	Were data entered correctly into SONRIS? <b>Y / N</b> COMMENTS:	
4	Was the same RSET instrument used as was used for previous data collection? Same RSET reader? <b>Y / N</b> COMMENTS:	
5	Were the correct number of observations recorded in each direction? <b>Y / N</b> COMMENTS:	
6	Were the same 4 collar and bearing directions used as previous? If not, Why? <b>Y / N</b> COMMENTS:	
7	Where elevation change differences calculated and comments compared to previous? <b>Y / N</b> COMMENTS:	
8	Were the elevation change differences reasonable (i.e. did the comments explain observations outside of the 95% CI)? <b>Y / N</b> COMMENTS:	
9	Were potentially unreasonable differences highlighted and discussed? <b>Y / N</b> COMMENTS:	
10	Were the means $\pm$ standard errors graphed for directions? Were any directions significantly different from the others? <b>Y / N</b> COMMENTS:	
11	Was there any apparent disturbance to the site or any RSET directions? If so, was it recorded in Site History file? <b>Y / N</b> COMMENTS:	
12	Are the calculations, comparisons, and explanations attached? <b>Y / N</b> COMMENTS:	
		Final QA Officer's Initials and Date

**Figure 4.5.** RSET QA/QC checklist

#### 4. Rod-Surface Elevation Table

Station ID	Group	Sample Date (mm/dd/yyyy)	Sample Time (hh:mm)	Establishment Date (mm/dd/yyyy)	Establishment Time (hh:mm)
CRMS05 13-E01		10/9/2007	10:44	6/7/2008	11:46
CRMS05 13-E01		10/9/2007	10:44	6/7/2008	11:46
CRMS05 13-E01		10/9/2007	10:44	6/7/2008	11:46
CRMS05 13-E01		10/9/2007	10:44	6/7/2008	11:46
CRMS05 13-E01		10/9/2007	10:44	6/7/2008	11:46
CRMS05 13-E01		10/9/2007	10:44	6/7/2008	11:46

(continued...)

Direction (Collar Number)	Direction (Compass Degrees)	Pin Number	Observed Pin Height (mm)	Verified Pin Height (mm)	SET ID
1	14	1	420		2005-1
1	14	2	406	406	2005-1
1	14	3	425	425	2005-1
1	14	4	406	406	2005-1
1	14	5	420	420	2005-1
1	14	6	407	407	2005-1

(continued...)

Organization	Personnel	Observation Comments	Verification Comments
Coastal Estuary Services LLC	L.Babin; C.A. LeBlanc; R. Broussard	On stick	
Coastal Estuary Services LLC	L.Babin; C.A. LeBlanc; R. Broussard		
Coastal Estuary Services LLC	L.Babin; C.A. LeBlanc; R. Broussard		
Coastal Estuary Services LLC	L.Babin; C.A. LeBlanc; R. Broussard		
Coastal Estuary Services LLC	L.Babin; C.A. LeBlanc; R. Broussard		
Coastal Estuary Services LLC	L.Babin; C.A. LeBlanc; R. Broussard		

(continued...)

Site Conditions
0.6 ft of water on marsh. Layer of thatch on marsh. Organic soil, spongy, pine laid on thatch. <i>Pontederia</i> and <i>Polygonum</i> dominant in plot. SAV present throughout the site.
0.6 ft of water on marsh. Layer of thatch on marsh. Organic soil, spongy, pine laid on thatch. <i>Pontederia</i> and <i>Polygonum</i> dominant in plot. SAV present throughout the site.
0.6 ft of water on marsh. Layer of thatch on marsh. Organic soil, spongy, pine laid on thatch. <i>Pontederia</i> and <i>Polygonum</i> dominant in plot. SAV present throughout the site.
0.6 ft of water on marsh. Layer of thatch on marsh. Organic soil, spongy, pine laid on thatch. <i>Pontederia</i> and <i>Polygonum</i> dominant in plot. SAV present throughout the site.
0.6 ft of water on marsh. Layer of thatch on marsh. Organic soil, spongy, pine laid on thatch. <i>Pontederia</i> and <i>Polygonum</i> dominant in plot. SAV present throughout the site.
0.6 ft of water on marsh. Layer of thatch on marsh. Organic soil, spongy, pine laid on thatch. <i>Pontederia</i> and <i>Polygonum</i> dominant in plot. SAV present throughout the site.

**Figure 4.6.** Post-processing format of RSET data

## **5. VERTICAL ACCRETION**

### **5.1 Introduction**

Vertical accretion/loss will be measured from marker horizon stations placed outside the boardwalk. The marker horizon, white feldspar clay that is easily distinguishable from the natural substrate, is evenly sprinkled on the surface of the wetland in sets of stations every two years. Stations will be sampled repeatedly over time to determine the rate of soil accumulation/removal over the marker horizon using cryogenic coring (Cahoon et al. 1996). After establishment, station sets will be sampled twice per year (late winter/early spring and late summer/early autumn) for two years (short-term period), then they will be transitioned to sampling every 1.5 years thereafter (long-term period).

### **5.2 Station Establishment**

Vertical accretion (VA) stations are established and initial RSET readings are recorded on the same day to synchronize both baselines for data analysis. Within a predetermined layout around the base boardwalk (Figure 5.1), a set of three, 50-cm x 50-cm stations are systematically established starting with the lowest available number within each side on the diagram (e.g., A01, A05, and A09). To standardize the age of accretion measurements, a new set of stations will be established coastwide every other Spring while continuing to sample previously established sets of stations every other year (Figure 5.2).

Each set of three stations established on the same date is referred to as plot set (PS). Coastwide establishment of plot sets began in Spring 2010 and will occur again in Spring 2012. Stations established prior to the first coastwide establishment were grouped into plot set 1 (PS1). Likewise, stations established in Spring 2010 are considered PS2. The sampling schedule for plot sets is designed to enable comparison of recently accreted material at all sites coastwide and to measure the accretion process over longer time scales at sites that maintain feldspar. Stations are sampled every six months during the initial, short term sampling period and less frequently in the long term sampling period. A process for deciding when to abandon accretion sampling in a plot set due to lack of available data has been established in an effort to balance sampling effort and data quality. As stations fail to produce accretion data after multiple attempts on repeated visits, the accretion sampling method is abandoned, first in the plot set, and then, if multiple plot sets have to be abandoned in the short term at a site, the process is abandoned at the site altogether. CPRA will provide a list of stations to be sampled each season based on stations assigned to each plot set and those that have been abandoned.

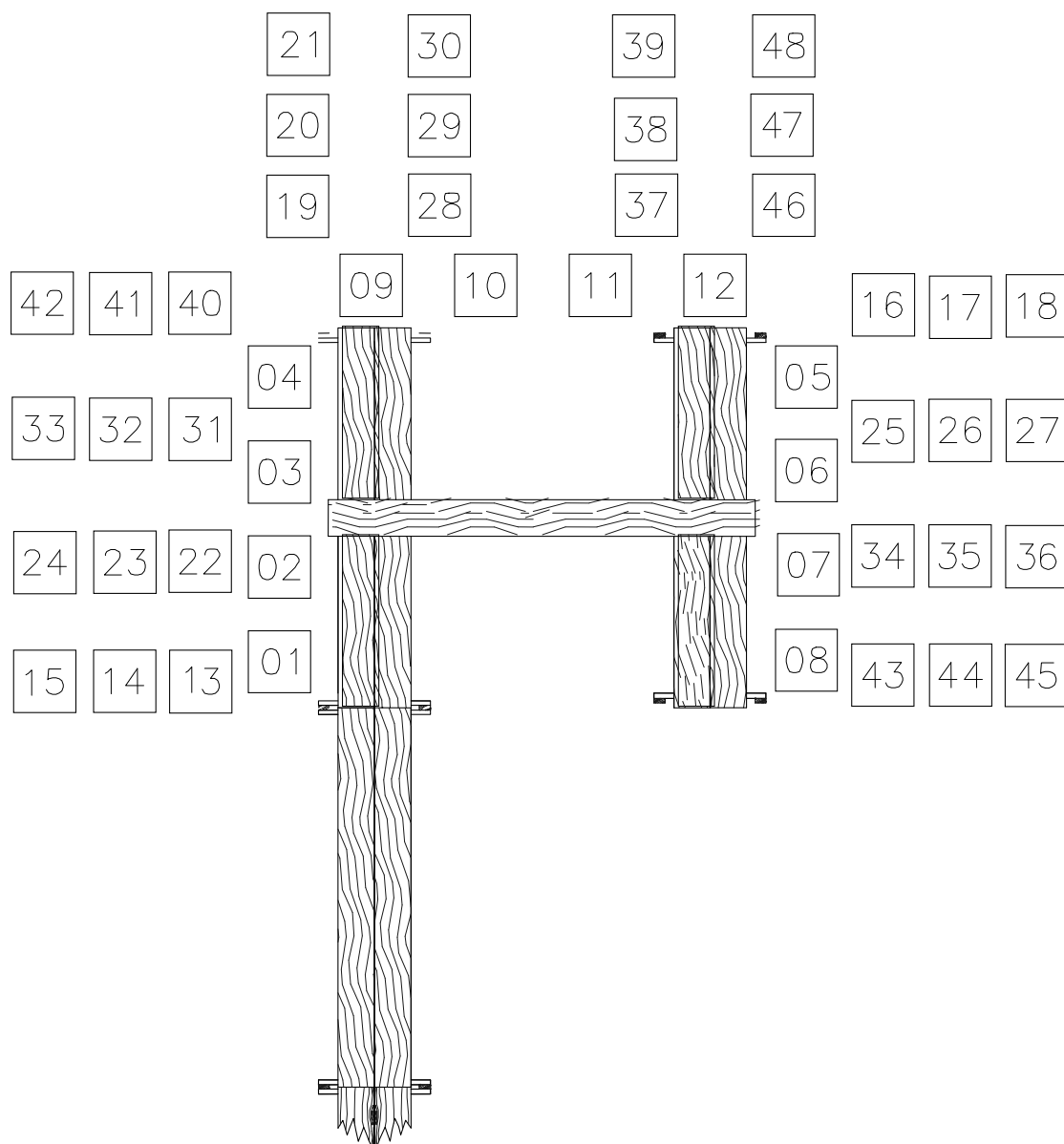
The vertical accretion method is not suitable for all coastal Louisiana habitats. The method is not used at floating marsh sites and some swamp sites. Some frequently inundated swamp sites can only be measured once per year. Those sites have to be

given special scheduling considerations, often making the trip coincide with the end of cold fronts in February. Problem sites should be discussed with CPRA.

Establish stations using the lowest station number available along each of the boardwalk sides (Figure 5.1). If a newly selected station is obstructed (e.g., disturbance, tree, hole, cypress knee), then select the next lowest number within that side. Because multiple plot sets will be active simultaneously, station numbers (A01, A05, etc.) should be marked and maintained on the station marker stake closest to the boardwalk with a permanent marker for identification.

Note: All station establishment and data collection procedures must be conducted from the boardwalk or portable boardwalks extending from the permanent boardwalk to avoid the disturbance of the marsh and future sampling areas.

Stations are established according to the two year coastwide establishment schedule (Figure 5.2) EXCEPT when no feldspar is found in both of the first two sampling attempts after establishment (at 6 months and 1 year). In order to prevent data gaps, a set of stations may be re-established during the second sampling trip after establishment (1 year after establishment) if no data was collected on the previous trip (at 6 months) and no data can be collected at one year. If stations are destroyed and cannot be located within the first year, they are also re-established. There are no other times when stations are re-established beyond the first year. From that point on, plot sets are abandoned altogether if they fail to produce data from any of the plots in two consecutive sampling periods or if they are damaged.



**Figure 5.1.** Schematic of the accretion stations around an attached marsh site. Portable boardwalks are to be placed between rows of stations when establishing or sampling stations that are not adjacent to the permanent boardwalk.

Sampling Season	Set of Stations (PS)									N stations to sample
	PS 1	PS 2	PS 3	PS 4	PS 5	PS 6	PS 7	PS 8	PS 9	
Pre Fa 09	E									0
	x			E = Establish new plots (n=3)						3
	x			x = sample plots (n=3)						3
Fa 09	x			x (E) = potential re-establishment						3
Sp 10	x	E								3
Fa 10		x								3
Sp 11	x	x (E)								6
Fa 11		x								3
Sp 12		x	E							3
Fa 12	x		x							6
Sp 13		x	x (E)							6
Fa 13			x							3
Sp 14	x		x	E						6
Fa 14		x		x						6
Sp 15			x	x (E)						6
Fa 15	x			x						6
Sp 16		x		x	E					6
Fa 16			x		x					6
Sp 17	x			x	x (E)					9
Fa 17		x			x					6
Sp 18			x		x	E				6
Fa 18	x			x		x				9
Sp 19		x			x	x (E)				9
Fa 19			x			x				6
Sp 20	x			x		x	E			9
Fa 20		x			x		x			9
Sp 21			x			x	x (E)			9
Fa 21	x			x			x			9
Sp 22		x			x		x	E		9
Fa 22			x			x		x		9
Sp 23	x			x			x	x (E)		12
Fa 23		x			x			x		9
Sp 24			x			x		x	E	9
Fa 24	x			x			x		x	12
Sp 25		x			x			x	x (E)	12
Fa 25			x			x			x	9

**Figure 5.2.** Typical establishment and sampling (short-term and long-term) schedule for accretion stations. Sets of stations (PS) are to be established in the late winter/early spring sampling season.



*Materials:*

1. Safety equipment: respirator, gloves, and eye protection
2. Feldspar for marker horizon: G-200 white feldspar clay from the Feldspar Corporation, Minspar 200 or equivalent (5–6 stations per 50-lb bag)
3. 50-cm × 50-cm PVC square with detachable corners
4. 5-ft stakes to mark opposite corners of the station (minimum of two per station): PVC pipes or other material except for metal rebar
5. Permanent marker for labeling stakes
6. Spreader/sieve: small cup-like device used to evenly spread the feldspar within the station
7. Container as large or larger than the square: Used when the marsh is flooded to prevent the feldspar from settling outside the station area
8. Watering can or garden sprayer: Used to moisten the feldspar on a dry marsh; must be able to moisten feldspar without disrupting an even feldspar layer
9. Digital camera: Capable of displaying a date stamp to document the establishment of the stations
10. Ruler: To measure depth of marsh surface flooding.
11. Differential Global Positioning System (DGPS) with sub-meter accuracy (Trimble GeoXT or equivalent): To take coordinates of corner station for verification and identification

*Procedures:*

Note for establishing stations beyond the first row: Do not disturb the surface of future stations, which extend approximately 10 ft from the sampling platform. The stations not directly adjacent to the boardwalk will be reached from a temporary boardwalk that extends perpendicularly from the boardwalk between rows of stations (figure 5.1). The type of temporary boardwalk will vary based on the type and/or condition of the marsh.

1. When applying the feldspar, all necessary health precautions should be taken because the material is a fine powder that can be easily inhaled and irritate the eyes. Note: An appropriate respirator, sealed eye protection, and gloves are required.
2. Document water level with respect to marsh surface and measure water depth if flooded.
3. Carefully place the 50-cm × 50-cm square on the soil surface illustrated in Figure 5.1 while not damaging the vegetation or disturbing the soil. Note: If vegetation is too thick and/or high, then the square can be disassembled, positioned around the vegetation, and reassembled.
4. Secure the square and mark the station for future measurements by lodging no less than two stakes into the soil just inside opposite corners of the square, leaving at least 2.5 ft above the surface. Note: Longer stakes may be required to leave 2.5 ft above the surface.
5. Record the station number on the stake with a permanent marker for future identification. Also, mark the approximate location on the boardwalk in case the stakes are lost.
6. Using a small cup or sieve, evenly sprinkle the feldspar on the marsh surface, making sure not to leave any on the standing vegetation or loose litter/thatch (vegetation can be gently shaken to remove any feldspar from the vegetation to the soil surface). Cover the soil surface with a minimum thickness of 5 mm or no less than 80 ounces (2.27 kg) of feldspar. Tip: Position yourself upwind from the station to avoid the clay dust, and pour the feldspar close to the soil surface to minimize the clay dust.
7. Ensure that the feldspar adheres to the soil surface:
  - a. If dry during station establishment, carefully sprinkle water to moisten the feldspar, being careful not to wash it away from the surface.
  - b. If flooded during station establishment, use a container to allow the feldspar to settle to the surface without drifting away from the station. Prior to applying the feldspar, place the container around the square and markers so there is no space between the soil surface and container. When the feldspar is applied, it has a tendency to float until it becomes completely saturated, which may take 15 minutes or longer. When the feldspar is no longer suspended in the water and has settled onto the soil surface (settlement time varies depending on water depth and movement and the soil surface), carefully remove the container to not disturb the

feldspar and to check that the feldspar is adhering to the soil surface. **NOTE:** It has been observed that containers that sit just below the water surface allow for faster settling than those that cross the water surface. If feldspar leaches out of the station, then replace the container to allow the feldspar more time to adhere to the surface. Repeat checking until no appreciable feldspar leaches; the purpose of this is to avoid the confusion of multiple feldspar layers in future stations. **Tips:** Having three containers will save time during feldspar deployment. Also, long settlement times at some sites may require multiple trips.

8. Photo document the establishment from directly above each station (pre/post establishment) and the location of the set of stations within the site (picture of the entire sampling platform showing the station markers). **Note:** Label the digital pictures (jpeg format) with the appropriate station number and establishment date. Name the files with the following convention: Site-station\_YYYY-MM-DD\_PS#.jpg (e.g., CRMS0395-A01\_2005-03-24\_PS1.jpg).
9. Record coordinates of each station from the corner closet to the boardwalk using a DGPS. The station coordinates (northing and easting) will be provided to the CPRA in UTM, NAD83 Meters using the “Station Coordinates” Excel file.

### 5.3 Data Collection

Sampling occurs twice per year (late winter/early spring and late summer/early fall) unless otherwise agreed upon by the CPRA. CPRA maintains a list of stations that are sampled once per year. VA will be measured at the same time as the RSET. Vertical accretion/erosion is determined by a cryogenic technique (Cahoon et al. 1996) that utilizes a 15–20 liter, self-pressurized, liquid-nitrogen dewar attached to a copper tube fitted with a tapered end (usually a .30 caliber/.308” diameter bullet) for easy insertion into the marsh (Figure 5.3). The bullet is inserted into the marsh to a depth deeper than the feldspar, and liquid nitrogen is injected into the tube to freeze a small sediment core. Once frozen, a sediment sample can be extracted from the marsh and up to four evenly spaced measurements are made from the feldspar layer to the surface. **Note:** For high water level/highly inundated sites (e.g., swamps), sampling trips should be timed to ensure that water levels are the lowest (i.e., the end of cold fronts in February).

Data are collected from a set of stations beginning with a short-term period of two years, with sampling every six months (Figure 5.2). If a set of stations is abandoned and a new set reestablished during the short-term period (see 5.2 Station Establishment), then retain the short-term schedule of the original set but be sure to update the “Establishment Date” of the new set in the database. After the short-term period, transition the set into the long-term period of sampling every 1.5 years with an interim 1-year sample (Figure 5.2).

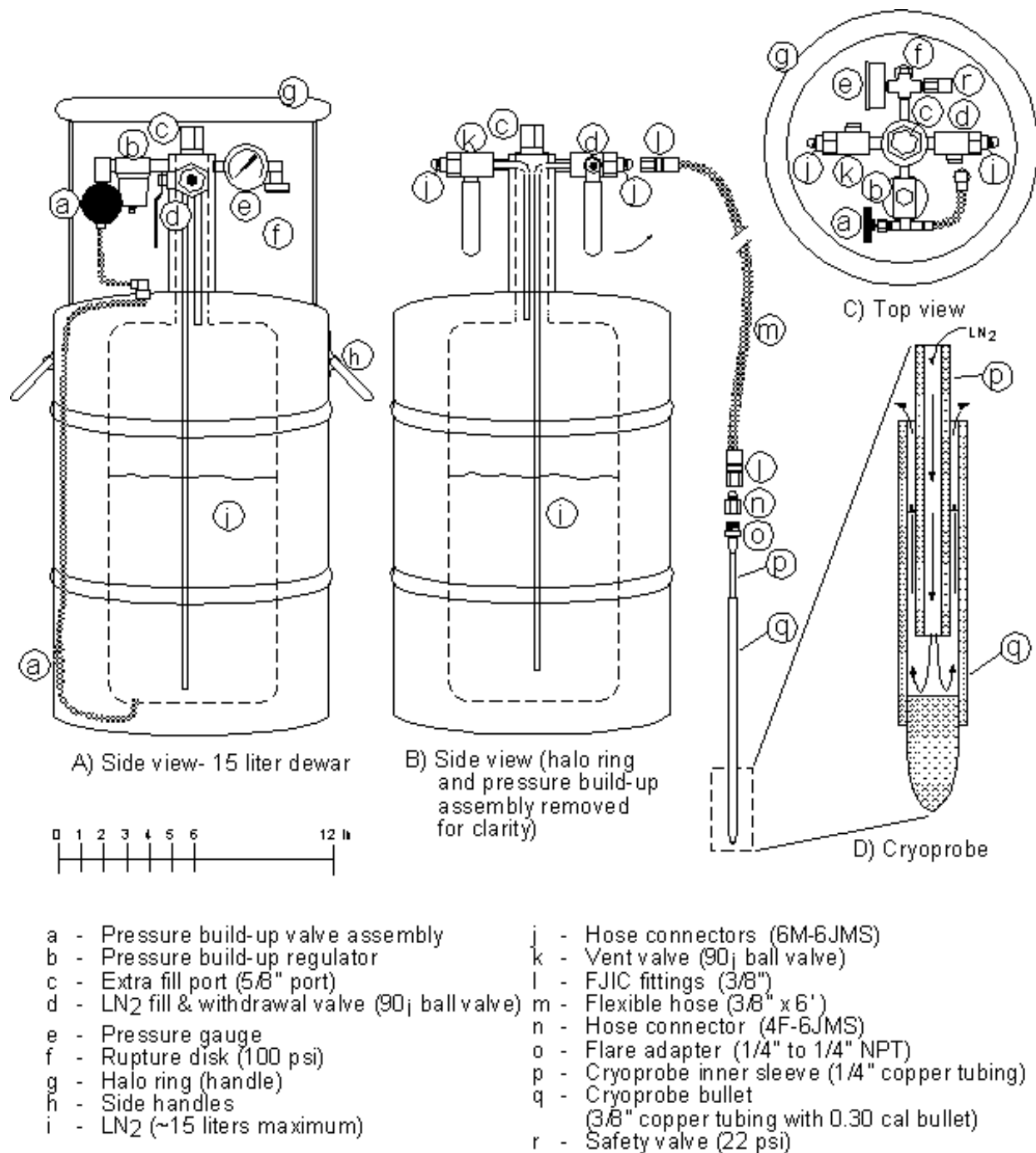
**Plot Set Abandonment:** Abandon a plot set when the plot set is deemed nonviable for two consecutive trips. Nonviable cores are defined as cores where no measurements or only one measurement can be taken (i.e. no feldspar or only a speck of feldspar can

be found). Up to three coring attempts can be made from a station during a sampling trip. If all three attempts yield nonviable cores, the station is nonviable. The plot set is deemed nonviable if all three stations are nonviable. A plot set is also abandoned if all 25 coordinates have been sampled. At any one time, there may be one set of short-term stations and multiple sets of long-term stations to be sampled as new stations are established every two years (Figure 5.2). When a station is abandoned, the stakes there should be removed to avoid confusion during future sampling trips.

**Sites sampled once per year:** At the swamp sites sampled once per year, the establishment schedule is the same as the other sites (every even year). These sites differ from the twice per year sampling schedule in that all plot sets will be sampled from these sites every year.

Defining the exact soil surface can be subjective, especially in organic soils and/or areas with a lot of plant litter or fallen thatch. It is critically important that a commonly defined surface be used for both the RSET and VA. The person measuring VA should coordinate with the person measuring the RSET to define the surface in order to maintain consistency between the two measurements that are later combined to describe elevation change processes. For example, a thin or thick layer of new organic deposition (thatch/litter) that has not been integrated into the soil often covers the surface. The person reading the RSET may be inclined to place pins beneath the thatch/litter. The person measuring VA should make sure they can differentiate the thatch/litter in the frozen core. When the marsh is flooded, it can be difficult to differentiate thatch/litter in a frozen core. If that is the case, the person reading the RSET should place pins on top of the thatch/litter layer. Also, when possible, the same combination of people should always measure a specific site to maintain consistency and familiarity over time.

Data are collected and recorded on a data sheet developed by the CPRA (Figure 5.4). In addition to the accretion measurements, describe the core conditions (quality of feldspar layer and unique notes about the core including prominent layers and features) for each core collected. Other notes to be collected about the station (if applicable) include: flooding or soil saturation if not flooded, soil composition and consistency, vegetation health, dominant species, root abundance, disturbance to the station, thatch thickness, whether accretion was measured above or below thatch layer, and any other observations.



**Figure 5.3.** Schematic for the cryogenic coring device developed by Cahoon et al. 1996. A) A side view of a 15-L low pressure nitrogen tank (dewar); B) The side view rotated 90° with a halo ring removed for clarity; C) A top view; D) An enlarged view of the cryoprobe used to collect the sample.

Make reasonable and safe attempts to measure VA and the RSET on the same day. Maintain your equipment in good condition and bring replacement equipment and tools in case of equipment failure or loss. Prevent running out of liquid nitrogen by bringing two full dewars. If completion of a task (RSET or VA) is not possible, then collect data from both tasks on the return trip even if repeating one of the tasks and check that the correct dates are entered into the spreadsheets.

(See “Note for establishing stations beyond the first row” in 5.2 Station Establishment–Procedure.)

The following materials list contains the minimum equipment necessary to collect quality data and the procedures that shall be followed for the cryogenic technique for sampling (see also [http:// www.pwrc.usgs.gov/set/](http://www.pwrc.usgs.gov/set/)).

*Materials:*

- a. Personal protective equipment (gloves and eye protection)
- b. Self-pressurized, liquid-nitrogen dewar and assembly (Figure 5.3)
- c. Stainless steel flexible hose, fittings, and appropriate wrenches
- d. Copper bullets (12” and 18”)
- e. 50-cm × 50-cm square (also used during station establishment)
- f. List of randomly selected and previously sampled coordinates
- g. Data sheets (Figure 5.4)
- h. Knife for scraping cryo-core and potentially cutting core out of roots
- i. Calipers: High quality stainless steel that measure up to 150 millimeters (mm) in increments no greater than 0.02 mm
- j. Digital camera
- k. Metric ruler (meter stick)

Vertical Accretion Measurement Data Sheet												
Site: _____			Group: _____			Establishment Date: _____			Time: _____			
Organization: _____			Sample Date: _____			Time: _____						
Measured by: _____			Other Personnel: _____									
Station: _____					Core Conditions							
Core Coords (X:Y)		Accretion Measurements (mm)				Feldspar Quality (Solid/Broken/None)		Notes				
		1	2	3	4							
Add'l Notes: Water level: _____ cm; if not flooded: (wet / dry)      Vegetation: healthy/senesced/stressed/dead												
Roots: Abundance (none / high / med / low)						Dominant spp. _____						
Soil Desc: organic / mineral (sandy / silty / clayey)						Consistency: firm / soft / unconsolidated				Disturbance (if any):		
Thatch thickness (if any): _____ cm; Measured to: top of / beneath								Human				
Other: _____								Grazed				
								Burned				
								Animal tracks/nest				
Station: _____					Core Conditions							
Core Coords (X:Y)		Accretion Measurements (mm)				Feldspar Quality (Solid/Broken/None)		Notes				
		1	2	3	4							
Add'l Notes: Water level: _____ cm; if not flooded: (wet / dry)      Vegetation: healthy/senesced/stressed/dead												
Roots: Abundance (none / high / med / low)						Dominant spp. _____						
Soil Desc: organic / mineral (sandy / silty / clayey)						Consistency: firm / soft / unconsolidated				Disturbance (if any):		
Thatch thickness (if any): _____ cm; Measured to: top of / beneath								Human				
Other: _____								Grazed				
								Burned				
								Animal tracks/nest				
Station: _____					Core Conditions							
Core Coords (X:Y)		Accretion Measurements (mm)				Feldspar Quality (Solid/Broken/None)		Notes				
		1	2	3	4							
Add'l Notes: Water level: _____ cm; if not flooded: (wet / dry)      Vegetation: healthy/senesced/stressed/dead												
Roots: Abundance (none / high / med / low)						Dominant spp. _____						
Soil Desc: organic / mineral (sandy / silty / clayey)						Consistency: firm / soft / unconsolidated				Disturbance (if any):		
Thatch thickness (if any): _____ cm; Measured to: top of / beneath								Human				
Other: _____								Grazed				
								Burned				
								Animal tracks/nest				

Figure 5.4. Example of a vertical accretion (VA) field data sheet.

*Procedures:*Sample Collection:

Before the sampling season begins, plan to collect the VA cores in a controlled manner in order to not sample a previously cored location. Each station (50 cm × 50 cm) is intended to be visually subdivided into an evenly spaced, X;Y-coordinate grid with each coordinate being a sample location (25 locations: 1;1 to 5;5). Make a list of all 25 randomly selected coordinates for each station, being careful to exclude or note previously sampled coordinates. Use this list to dictate which coordinate to sample on the next sampling trip, and update the list to exclude newly sampled coordinates. To aide in creating a visual grid, mark the square to create five equal sections on each side.

Prior to the sampling field trip, review notes and data sheets from the previous sampling trip to be prepared for local conditions and to establish new stations if needed. Normally, two lengths of sleeves and bullets are made (12" and 18"); however, at some locations a longer sleeve and bullet will be required based on the amount of sediment that has accumulated on top of the feldspar and the depth of water on the marsh surface. Do not collect VA or RSET data if the surface layer of soil cannot be identified because (1) it is separated from the substrate if you are not in a known floating marsh or (2) there is a slurry of mud between the soil surface and water surface. Return to the site to measure when water levels are low enough for the surface to be identified. Decisions to change the timing or to discontinue sampling of a CRMS site will be made in consultation with CPRA on a case-by-case basis.

Upon arrival to the site, follow these steps for sample collection at each site:

1. Complete the top portion of the data sheet: *Site, Group (PS#), Establishment Date and Time, Sample Date and Time, Organization, Measured by, and Other Personnel.*
2. List the appropriate station being sampled.
3. Connect the appropriate hose and fittings to the dewar.
4. Don the personal protective equipment to prevent any injuries. Gloves and eye glasses are required when handling extremely cold items (bullet and hose from liquid nitrogen) and knives. **CAUTION:** The liquid nitrogen and frozen metal equipment can cause serious burn injuries when in contact with bare skin. **Tip:** Wrap the liquid nitrogen hose with foam insulation to prevent contact with skin.
5. Place the 50 cm x 50-cm square over the stakes that mark the station location, taking care to not damage the vegetation. Insert the inner core sleeve completely into the bullet to protect the sleeve and prevent any disturbance once the bullet penetrates the marsh surface.
6. From the list of coordinates, find the core location within the station using the evenly marked sections on the square (position 1;1 is the bottom, left corner of the square as you face the station from the boardwalk). On the data sheet, record the station number and coordinate. If the position is obstructed, record



this on the data sheet and try the next coordinate on the list. Note: Make sure these coordinates have not been cored previously.

7. Push the bullet with the inner core straight into the soil as close to the middle of the section as possible (avoid standing vegetation or other obstructions). The bullet should be deep enough to freeze the feldspar and sediment to the bullet; this depth varies but can be estimated by reviewing previous feldspar depths. Do not rock or move the bullet once it penetrates the surface. The soil surface must remain in contact with the bullet for this process to be effective. Note: This is difficult to achieve when leaning over the station. If the surface of the marsh is not frozen to the bullet, then the surface will appear to “dip” where the underlying soil was frozen to the bullet. Avoid measuring this portion of the core.
8. Open the valve on the dewar and start the flow of the liquid nitrogen into the bullet.
9. Allow the marsh to freeze around the bullet. Normally the core is frozen when steam streams from the top of the bullet. Note: It may be best to let the liquid nitrogen run a bit longer until the person using it has experience with this procedure.
10. Turn off the dewar when the core is frozen.
11. Remove the inner sleeve from the bullet and place it into another bullet or some other protective sheath. Be very careful with the hose, as it becomes very brittle once it is frozen and may break if kinked.
12. With gloved hands, grab the top of the bullet and pull the core straight up and out of the marsh, being cautious to not disturb adjacent marsh. Note: Roots around the core may need to be cut before extruding the core from the soil.

*Alternative method:* If equipment failure prevents frozen core collection or the soil is too dry, then, under the right conditions (non-flooded, firm/consolidated soil), a soil plug can be cut out with a knife. Cut a large enough area within the position to allow for prying out the plug. After removing the plug, proceed as normal with data collection, note that the soil plug technique was used, and return the soil plug to its hole.

#### Data Collection:

After collection of the frozen core (also known as “cryo-core” or “marshsicle”), follow these steps for data collection, being sure to record all data on the data sheet (Figure 5.4). Note: Multiple data sheets may be needed depending on the number of sets that are active.

1. Find the feldspar layer. It may be necessary to carefully scrape the core starting from the bottom and working towards the soil surface to avoid disturbing the soil above the feldspar layer. Note: Do not scrape the core over the VA or RSET stations because the soil addition may affect future measurements.
2. Document the quality of the feldspar layer (ability to measure from the feldspar layer to the surface) in the “Feldspar Quality” column based on completeness of the visible ring (broken, solid, or no feldspar).

Note: If a minimum of two different measurements can be made, then continue to step 4. If insufficient feldspar (only one measurement location or no feldspar) is found to reliably estimate accretion, then attempt another core from the list of remaining coordinates.

Note: A minimum of three attempts (cores) to find acceptable feldspar per station is required; after three unsuccessful attempts the station is deemed nonviable for this sampling trip. Do not attempt to extract more than three cores from a station on a sampling trip.

3. Space the measurements around the core as evenly as possible (four right-angle measurements are optimal). Measure the distance (mm) from the top of the feldspar layer to the soil surface using the calipers, and record data in numbered columns under *Accretion Measurements (mm)*. Notes: (1) Record a zero if the feldspar layer is visible on the soil surface; draw a line through the data cell if a measurement is not taken. Zeroes mean no measurable sediment is on the feldspar. (2) Refreeze the core if it begins to thaw before data collection is complete.
4. Record any other unique notes about the core (e.g., odor, color, prominent layers including storm deposits and their thickness) under the *Notes* column.
5. Record other information about the core and station conditions (flooding, roots, soil, vegetation, disturbance, thatch thickness) as prompted by the data sheet or otherwise observed by the field personnel. Notes: (1) When establishing a new set of stations, record new station label and coordinates in the "Other" section. (2) If stations are losing feldspar, then suggest why in the "Other" section. (3) Take pictures of unique observations.
  - a. If it appears that all of the surface water was frozen onto the bullet when extracting the core, flooding can be measured from the core. Otherwise measure flooding with a ruler on the surface of the station.
  - b. If there are no pertinent root health or abundance notes, those fields on the data sheet can be left blank.
  - c. Thatch refers to dead stems that are on top of the soil surface. The RSET and accretion should both be measured to the same surface relative to thatch. Collection of other notes beyond the prompted notes is encouraged.
6. When possible, return the frozen core back to its hole. If this process is done properly, a hole or other disturbance will not be left in the soil where the sample was taken. Note: Do not place the core on the soil surface in the vicinity of the VA or RSET stations.
7. The station has been sampled when one of the following conditions is met: a core is extracted and a minimum of two measurements are collected, or a minimum of three sampling attempts have been made.
8. Before leaving each site, field data sheets are to be examined for clarity and completion. Any information that was not completed on the boardwalk should be completed prior to leaving the site.

**CONVERSION OF STATIONS TO OPEN WATER:**

The intent of the CRMS monitoring program is to maintain the original monitoring stations for as long as possible. Accretion stations will not be moved to new locations if the original location erodes away. The rules for station establishment and re-establishment provide a condition for when to abandon the feldspar method at a site. If stations wash away rapidly, CPRA may provide guidance to abandon the method sooner. Accretion will be measured at the original station locations for as long as possible.

**5.4 Data Processing**

The CPRA has a two-phase protocol for data processing: data entry (Phase I) and data quality assurance/quality control (Phase II). Separate individuals conduct these two phases to assure that the final product is in 100% agreement with the data collected during the field sampling procedure.

**DATA ENTRY (PHASE I):** Phase I is conducted by the individual responsible for the field data collection and requires following three main tasks: 1. field data sheet review, 2. data transcription, and 3. data verification. These tasks require specific procedures necessary to satisfy the deliverable requirements. Below are the procedures for each task:

1. Field Data Sheet Review
  - a. Review the field data sheet for legibility, completeness, and accuracy.
  - b. Make corrections using a different color pen without erasing original data. If an error needs to be corrected, then strike a single line through the error and write the changes close to the error. Note: The original data should still be legible after corrections are made.
  - c. Accompany changes with the responsible person's initials and date.
2. Data Transcription
  - a. CPRA has developed a data upload tool that allows the user to enter data into a Microsoft Excel spreadsheet that looks like the field data sheet. The Excel file transfers the data from the digital data sheet into a spreadsheet that is formatted for upload to SONRIS. The file, "Acc\_data\_tool.xls," is available on the CPRAFTP site.
  - b. Enter recently collected data into the "1\_ Data Sheet," which is formatted to look like the field data sheet.
    - i. The prompted drop-down boxes in the "Notes" section are the minimum station notes required.
  - c. Data entered into the "1\_ Data Sheet" will automatically populate "to SONRIS" which may be saved as a .csv file to upload to SONRIS through the CPRA FTP site.

- d. Save a copy of the Acc data tool to the CPRA FTP site using the following naming convention: “*Station\_Acc\_data\_tool\_seasonYEAR\_PS#.xls*”, e.g., “CRMS0398\_Acc\_data\_tool\_Spring2012\_PS1.xls”.
3. Data Verification
    - a. Double-check “1\_ Data Sheet” for accurate transcription.
    - b. Check that the data was automatically populated to “to SONRIS” correctly and in a clear fashion. Especially check that the “Notes” section merged clearly and that the “Measured by” name on the data sheet is the first person listed under “Personnel.”
    - c. Upon completion of Data Entry (Phase I), the field data sheet along with the electronic file shall be provided to the QA/QC officer.

**QUALITY ASSURANCE/QUALITY CONTROL (PHASE II):** Phase II begins when the QA/QC officer is provided with the field data sheet and is notified that the Excel file has been completed. The QA/QC officer should follow the steps below to ensure the data has been processed properly. However, the completed QA/QC Checklist is not a deliverable. The QA/QC Checklist template is provided in Figure 5.5 and is also available as an Excel file (QAQC Checklist Form template 03022005.xls).

The QA/QC officer should complete the following procedures:

1. Examine the field data sheet for completeness and errors.
2. Check the data from the “1\_ Data Sheet” worksheet against the field data sheet to ensure it was correctly entered into the Excel file.
3. Check that the data was automatically populated to “to SONRIS” correctly and in a clear fashion.
4. If mistakes are found, return the field data sheet and Excel file to the data collector so any mistakes can be corrected or explained.
5. Continue this process until no mistakes are found.
6. Scan a copy of the corrected data sheet into a .pdf file for upload to the CPRA FTP site.
7. Check that the data was automatically populated to “to SONRIS” correctly and in a clear fashion.
8. If mistakes are found, return the field data sheet and Excel file to the data collector so any mistakes can be corrected or explained.
9. Continue this process until no mistakes are found.
10. Scan a copy of the corrected data sheet into a .pdf file for upload to the CPRA FTP site.

Once Phases I and II have been completed, save the final version of the “to SONRIS” worksheet from the “Acc\_data\_tool.xls” as a .csv file using the naming convention: “*Station\_Acc\_seasonYEAR\_PS#.csv*”, e.g., “CRMS0398\_Acc\_Spring2012\_PS1.xls” for data upload to CPRA’s FTP site.

<b>QA/QC CHECKLIST</b>							
DATA TYPE: <input type="checkbox"/> RSET <input type="checkbox"/> Accretion <input type="checkbox"/> Forest <input type="checkbox"/> SAV <input type="checkbox"/> Herb. (Natural) Vegetation <input type="checkbox"/> Herb. (Planted) Vegetation							
PROJECT: _____				Data Collection Date(s): _____			
SITE / STATION(S): _____				Date Received: _____			
_____				Date QA/QC Completed: _____			
Data Collection Personnel: _____							
Data Entry Personnel: _____							
						QA/QC Initials	DNR QA/QC
1	Was a field trip report generated? <span style="float: right;">YES / NO</span>						
2	Did the field trip report have the required information, the correct information, and the proper format?						
		YES (DATE)	NO (DATE)	Comments			
A	Project						
B	Basin						
C	Purpose						
D	Field Personnel						
E	Date(s) of Trip						
F	Weather Conditions						
G	Logistical Information						
H	Biological Information						
I	Format						
3	Were the data sheets filled to completion? <span style="float: right;">YES / NO</span> If no, then add comments or indicate on the copied data sheets.						
4	Were the data entered into the Excel spreadsheet correctly? <span style="float: right;">YES / NO</span> If no, then add comments or indicate on the copied data sheets.					Applicable YES / NO	
5	Were the data entered into SONRIS correctly? <span style="float: right;">YES / NO</span> If no, then add comments or indicate on the copied data sheets.					Applicable YES / NO	

**Figure 5.5.** QA/QC checklist.

## 5.5 Deliverables

Electronic files containing the data shall be in the appropriate deliverable format (Figure 5.6) and delivered to CPRA once the data has completed the QA/QC process.

Deliverables should include the following:

Accretion data file (*Station\_Acc\_seasonYEAR\_PS.csv*)

Accretion original field data sheet (*Station\_Acc\_seasonYEAR\_PS.pdf*)

Accretion data tool (*Station\_Acc\_data\_tool\_seasonYEAR\_PS.xls*)

Photography (*Station\_Acc\_seasonYEAR\_PS description.jpg*)

Station ID	Group	Sample Date (mm/dd/yyyy)	Sample Time (hh:mm)	Establishment Date (mm/dd/yyyy)	Establishment Time (hh:mm)
CRMS0000-A001	PS 1	1/1/2009	9:00	1/1/2006	8:00

(continued...)

Core X;Y	Accretion Measurement 1 (mm)	Accretion Measurement 2 (mm)	Accretion Measurement 3 (mm)	Accretion Measurement 4 (mm)
1;1	25	30	37	29

(continued...)

Core Conditions	Organization	Personnel	Notes
Excellent (Solid Feldspar; n=4); 15 mm of storm surge deposition above feldspar	Contractors Name	J. Troutman; T. Folse	Marsh balls from Hurricane Ike rooting around the site.; Site is flooded 5 cm; Vegetation is healthy; Dominant spp. are spartina patens; Root Abundance is high. Roots appear healthy.; Firm organic soil; Thatch 2 cm thick. Accretion measured to beneath thatch; Disturbance: (Animal tracks/nest) deer trail;

**Figure 5.6.** Accretion data format in .csv file and SONRIS

## 6. MAINTENANCE

Once a site has been constructed and construction has been approved, the site must be maintained for safety and for accurate data collection. Those items that have not been identified as routine maintenance through contract negotiations will be repaired or replaced under the contract maintenance provision. In order for work to be performed and paid for under the maintenance provision, proper procedures shall be followed. These procedures are outlined below:

1. The field crew shall document all items that need to be repaired or replaced in the field.
2. Photos shall be taken of the damage.
3. The contractor shall prepare a cost estimate using the form provided by the CPRA. This form will be agreed upon by the contractor once the contract has been implemented. This cost estimate should be developed in Excel, but the final product shall be saved as a PDF document for submission to the CPRA. The cost estimate should have at least the following elements:
  - a. Station/site
  - b. Field office
  - c. Contract manager's name
  - d. Date cost estimate submitted
  - e. Description of damage
  - f. Description of work needed
  - g. Cost breakdown, including time required to perform the maintenance
  - h. Materials list
  - i. Cost estimate
4. Once the cost estimate has been generated, the file shall be saved as a PDF document and photos obtained from the field shall be inserted with a description underneath each picture.
5. The PDF shall be saved to the CPRA FTP site and an e-mail notification sent to the CPRA field supervisor.
6. The field supervisor will review the estimate and send an email to the CPRA manager for approval.
7. Upon approval by the CPRA manager, an e-mail correspondence is sent to the contractor's O&M manager, the contractor's field manager, and the CPRA field supervisor.
8. Work is then conducted in the field. Photos are taken to document the work.
9. Using the Excel file that was used to generate the cost estimate, another worksheet shall be completed that links to the cost estimate worksheet, documenting the actual repairs made in the field.
10. The worksheet shall be saved as a PDF and the photos shall be inserted that document the work that has been completed.
11. The PDF shall be saved to the CPRA FTP site and an e-mail notification shall be sent to the CPRA field supervisor for review and approval.
12. Once the PDF has been approved, the CPRA manager will include the worksheet on the next invoice summary, which will be used for payment.

## 7. VEGETATION

### 7.1 Emergent Vegetation Sampling

The objective of CRMS vegetation sampling is to spatially and temporally describe the vegetative community of Louisiana's coast and assess the relative vigor of the dominant species. The relative vigor of the vegetation will be assessed annually, using the total vegetative cover and the average height of the dominant plant species.

#### 7.1.1 Methods

There are 10 vegetation stations (plots) at each CRMS site. Vegetation transects are oriented diagonally across the 200 m square data collection area, either NW to SE or NE to SW. Transects are established away from spoil banks or any type of human-induced surface alterations to avoid biased data. CPRA will provide a randomized vegetation station list with coordinates of all established and potential vegetation sampling stations. At each CRMS site, there are 85 potential vegetation stations, one every 3 m on a 288 m transect and excluding those within 10 m of the boardwalk or near the edge of the 200 m square. These stations have been named according to their spatial order, where CRMS0000-V01 is farthest north and -V85 is farthest south. When naming these stations, the initial, spatially related order number is always used, not the random order number. The ten stations initially established are maintained throughout the life of the CRMS project.

#### **STATION ESTABLISHMENT:**

##### *Materials:*

This list of equipment and supplies is needed to establish and to sample vegetation stations in herbaceous wetlands. Other equipment and/or supplies may be necessary depending on the site.

4. PVC pipes: ½" diameter or larger 10-ft pipes used as station locators
5. 2 m x 2 m PVC square
6. 4 Meter Telescopic leveling rod and meter stick
7. Compass: 0° to 360° azimuth dial with 2° graduations
8. Randomized vegetation station list provided by CPRA
9. Differential GPS (DGPS) sub-meter accuracy (Trimble GeoXT or equivalent)
10. Materials for creating a sign to be included in the site photos (Dry erase board and markers or other).
11. Field notebook
12. Vegetation and porewater data sheets
13. Copy of the previous year's vegetation data sheet
14. Plant reference books
15. Zip lock bags for unknown plants
16. Ice chest for plant samples



17. Digital camera capable of capturing 8 MP or better photographs for recording station number and vegetation in plot
18. Porewater sipper, syringe, and centrifuge tubes
19. YSI 30 to measure soil porewater
20. Conductivity standard
21. Permanent markers

Field personnel should reference the randomized vegetation station list to determine the location of the first vegetation plot. The first station located is the initial order number associated with random order number “1.” The field crew should stay on the east side of the transect when it runs from NE to SW. Crews can access transects that run from NW to SE from either side but should provide a buffer between the access route and the station. A 10 m buffer should be maintained between the boat and the vegetation station if at all possible. Once the station is located, a PVC pole should be installed at the station coordinate, marking the southeast corner of the vegetation plot. The 2 m x 2 m PVC quadrat should then be placed around the plot so that the pole is the southeast corner of the quadrat and one side is facing due north. If the plot is  $\geq 55\%$  land, the plot will be selected and sampled. If the plot is  $< 55\%$  land, the plot will not be used and the crew will replace it with the next random order number. This process will be repeated until all 10 stations are established and this protocol will be utilized if stations need to be replaced.

**DATA COLLECTION:** Annual vegetation sampling shall occur during the 8-week period between August 1 and September 30. The 8-week time period should be sufficient to collect data for the herbaceous wetland community; however, flexibility of the September 30<sup>th</sup> deadline may be allowed for unforeseen events. Scheduling consideration should be given to sites with restricted access by landowners because of hunting seasons; these sites should be sampled prior to restricted times, duck season in particular.

Data sheets will be utilized for recording herbaceous wetland community and porewater at each vegetation station. At least two personnel must be present and both participating in estimating cover percentages at each station.

Note that the method for collecting herbaceous vegetation data is slightly different in swamps than in marshes. In swamps, the tree layer is quantified separately in larger plots so the herbaceous plots don't include tree information.

### Data Collection Procedure:

1. Using the “Herbaceous Marsh Vegetation Sampling Data Sheet” or the “Herbaceous Swamp Vegetation Sampling Data Sheet” (Figures 7.1 and 7.2), completely fill out all the site information (i.e., sample type, project, station, group, personnel, plot size, date, station coordinates, organization, and plant community type) before beginning the collection of data at the station.

2. Place the 2 m x 2 m PVC quadrat such that the pole is the southeast corner of the quadrat. One side will be facing due north. When collecting data using this method, project four geometrical vertical planes (square) from the soil surface to the sky and document the percent cover for any species within the 2 m x 2 m square. This includes plants rooted outside but hanging in the quadrat.
3. Take a high quality photo of the plot from the SE corner. The photo should be at least 8 megapixels. The picture should contain the sign with the station name, plot number, and date. It should also contain the 2 x 2 and pole in the SE corner. The objective is to obtain a full-plot photo. Do not block the view of the vegetation with the sign, person, or other obstruction.
4. Estimate to the nearest whole number the total % cover of live vegetation in the plot. Total percent cover in marshes includes tree, herbaceous, shrub, and carpet layers. In swamps, the tree layer is excluded from total cover. Total % cover must be between 0 and 100% and must meet the following parameters:
  - a. Cannot be > 100%.
  - b. Cannot be > the sum of the % covers of the individual species.
  - c. Cannot be < the % cover of any one plant species present.
  - d. When only one species is present, the % cover of that species should = the total % cover.
  - e. Vegetation rooted outside of, but hanging over the plot is included in the estimate of total % cover.
5. The portion of the plot not covered by the vegetative layers estimated should be described in detail in the “Unvegetated Surface” portion of the data sheet.

The following descriptors should be used to define the unvegetated area:

- a. Open water—an area with insufficient elevation to support emergent vegetation. This classification is determined by professional judgment but in certain marsh types can be consistently identified. For example, in *Spartina patens*-dominated marshes there is usually a definable pond edge where the elevation drops well below the marsh platform. Record the percent of the 2 m x 2 m plot that is open water.
- b. Bare ground— an area devoid of vegetation but may be of sufficient elevation to support emergent vegetation.
- c. Dead vegetation— an area devoid of live vegetation. The wetland surface is covered with dormant, dead, or dying vegetation.
- d. Flooded-Undetermined—used in cases where the wetland may be flooded too deeply to accurately determine the wetland surface and where it is obvious that there is no live or dead vegetation.

In swamps, also note the percentage of the plot that is covered in tree trunks and cypress knees.

6. Estimate to the nearest whole number the % cover of live vegetation in the plot for individual layers (trees, herbaceous, shrub, carpet), using these guidelines:
  - a. Percent cover of each layer must be between 0 and 100%.
  - b. Cannot be > 100%.
  - c. Cannot be < the % cover of any one plant species present within that layer.
  - d. If there is only one layer present, % total cover should = the % cover of that layer.
  - e. Sum of layer % covers (tree, shrub, herbaceous, carpet) can be > 100% because of overlap.
  - f. Vegetation rooted outside of, but hanging over the plot is included in the estimate of % cover for each layer estimated.
  
7. A combination of professional judgment and the following general guidelines will be used to delineate tree, shrub, herbaceous, and carpet layers:
  - a. Tree: has a DBH (diameter at breast height)  $\geq 5$  cm. However, if a tree species is close to 5 cm DBH and is > 4 m tall, then best professional judgment would likely classify the species as a tree. Diameter at breast height is measured at 4.5 ft above ground.
  - b. Shrub: if the plant is woody, < 5 cm DBH, and is between 50 cm and 4 m tall.
  - c. Herbaceous: if the plant is woody, < 5 cm DBH, and  $\geq 10$  cm but < 50 cm tall.
  - d. Herbaceous: emergent marsh vegetation is  $\geq 10$  cm but < 50 cm tall. Certain exceptions apply. For example, 3 m-tall *Typha* or *Phragmites* would be categorized in the herbaceous layer even though they are outside of the height category.
  - e. Carpet: < 10 cm height.
  
8. Identify and record all species that fall **IN** the plot.
  - a. Project the boundaries of the 2m x 2m square plot up through all of the vegetative layers. All plants contained by and overhanging the plot boundaries are considered IN.
  - b. Species should not be identified to the variety level.
  - c. Trees:
    - i. A tree is defined as having a diameter at breast height (DBH)  $\geq 5$  cm.
    - ii. In herbaceous marsh plots, trees are included in the species list; the cover of each species is estimated along with the cover of the overall tree layer. Trees are included in total cover.
    - iii. In herbaceous swamp plots, trees are not included in the species list and the tree cover layer is not estimated. Data on specific trees is collected more precisely in the larger overstory and understory data

sets in the forests. The herbaceous plots are meant to quantify the forest floor. However, an estimate of canopy cover and tree trunk cover in the swamp herbaceous plots is a helpful note and should be included in the Ancillary Data at the bottom of the data sheet (figure 7.2). Additionally, tree species occurring inside the plot and their tag numbers are to be recorded in the notes along with a list of tree species occurring outside the plot within 10 m of the plot.

d. Unknowns

- i. For species that cannot be identified in the field, collect a full plant (with roots/fruits/flowers/seeds, if possible) to send to the plant taxonomist. Place unknown species in a labeled zip lock bag.
  - ii. For all unknown species, notes about the plant characteristics are required in Additional Species Description.
  - iii. Mark on the outside of the bag the station name, the date collected, and the unknown ID (example: CRMS0660-V56, 09/09/2011, Unknown #1). Place an ID tag (piece of duct tape) inside the bag and record on it the station ID, date collected, and unknown ID. The same unknown species does not need to be recollected along the transect, as long as it can be positively identified as the same unknown species.
  - iv. Comments received from the plant taxonomist regarding unknown species must be entered into the Additional Species Description field. It must be noted if a species cannot be identified or can only be identified to the genus level. If there is some uncertainty about the identification, a note should be made that "Dr. XYZ thinks it is "x" species with "y" degree of certainty."
9. Identify all species within 15 ft (5 m) of the plot (**OUT**). Only record species that are not already included in the list.
  10. Assign IN/OUT/BOTH categories to all species in the list. If a species occurs both IN and OUT of a plot, it is recorded as BOTH. If a species is rooted OUT of the plot, but is hanging over the plot, it is also recorded as BOTH.
  11. Estimate to the nearest whole number the % cover of all live vegetation species **IN** the plot. Note that the database converts cover data to the Braun-Blanquet cover scale (Mueller-Dombois and Ellenburg 1974) (Table 7.1).
    - a. Estimates should be made with the plants "as is" (i.e., if the plants are lying over, that is how the % cover estimate needs to be evaluated).
    - b. Include species both rooted and hanging in the plot.

- c. Do not estimate % cover for species outside (OUT) of the plot.
  - d. Estimates should reflect the opinions of at least two people.
  - e. The sum of the % covers for individual species can be > 100% since the cover of species can overlap within the plot.
  - f. The total % cover cannot be > 100% and cannot be > than the sum of the % covers of the individual species.
12. If floating SAV is present inside or outside of the plot, identify it to species and record in the Notes section. If the floating SAV is located IN the plot, also record its % cover in the Notes section. **DO NOT USE FLOATING SAV IN THE % COVER ESTIMATES FOR TOTAL, LAYER OR SPECIES.** If typical SAV species are rooted in the plot, they should be included in the species list and the cover estimates should contribute to vegetative layers.
  13. Measure 5 stem heights for the dominant species present (i.e. the species with the greatest % cover in the plot). Record the unit of measurement. If less than 5 specimens are in a plot, then measure those individuals and note how many were measured. The plants should be elongated vertically for height measurement. Vines should not be measured. If a vine is dominant, measure the next dominant non-vine species and make note of it. If there are 2 or 3 co dominant species with equal % cover, record in the Notes section which species was measured for stem height. Average the stem heights and record under Average Height: Dominant Height. This can be recorded at a later time.
  14. Measure the average height of each vegetation layer present (tree, shrub, herbaceous, carpet). The plants should be left “as is” for this measurement (i.e., if the plants are laid over that is how they should be measured).
  15. Collect one porewater sample at 10 cm and 30 cm at every vegetation plot (total of 10 plots sampled), and one additional porewater sample at the normal location at the CRMS boardwalk at both 10 cm and 30 cm (identified as station CRMS0000-P01). Refer to Section 3.2.2.2. Soil Porewater Data Collection for a complete description of collection methods. Porewater data should be entered on a *Discrete Hydrographic/Soil Porewater Data Sheet* (Figure 3.21) in the Soil Porewater section. Only one sheet is necessary for each CRMS site. Each porewater sample should be named using the number for the vegetation plot where the sample was collected (e.g., porewater collected at CRMS0135-V46 is named CRMS0135-V46). The samples collected at the boardwalk for the monthly servicing events do not change (CRMS0135-P01, P02, P03). If vegetation sampling coincides with monthly hydrologic servicing, collect three porewater samples for each depth at the boardwalk.
  16. Measure water level relative to the wetland surface at each vegetation plot and record under Ancillary Data. Record the unit of measurement.

## 7. Vegetation

Herbaceous Marsh Vegetation Sampling Data Sheet						
Modified Braun-Blanquet Technique						
Sample Type: Stratified _____ Random _____ Transect _____		Vegetation Type: NATURAL _____ PLANTED _____				
-----						
Project: _____		Station: _____		Group: _____		
Personnel: _____		Plot Size (m <sup>2</sup> ): _____		Date: _____		
Station Coordinates: _____		Organization: _____				
Plant Community Type: _____ Freshwater _____ Intermediate _____ Brackish _____ Saline _____ Swamp _____						
Percent Cover: Total Cover _____ % Tree _____ % Shrub _____ % Herbaceous _____ % Carpet _____ %						
Average Height: Dominant Height _____ (cm) Tree _____ (cm) Shrub _____ (cm) Herbaceous _____ (cm) Carpet _____ (cm)						
Species List						
Present	Scientific Name	Common Name	% Cover	IN / OUT	Additional Species Description	
	B-B Rank: (5) 76-100%, (4) 51-75%, (3) 26-50%, (2) 6-25%, (1) 1-5%, (+) <1%, (r) Solitary					
	Ancillary Data: Photo(s) obtained (circle one): Yes / No ; camera stamp name: _____					
Dominant height of stems: ft / in / cm (1) _____; (2) _____; (3) _____; (4) _____; (5) _____						
Unvegetated Surface: Open water _____ % Bare ground _____ % Dead vegetation _____ % Flooded-Undetermined _____ %						
Water relative to marsh: _____ ft / in / cm. Above or Below (circle one) Floating Marsh? Yes / No						
Notes:						

**Figure 7.1.** Herbaceous marsh vegetation sampling data sheet.

## 7. Vegetation

Herbaceous Swamp Vegetation Sampling Data Sheet						
Modified Braun-Blanquet Technique						
Sample Type: Stratified _____ Random _____ Transect _____		Vegetation Type: NATURAL _____ PLANTED _____				
-----						
Project: _____		Station: _____		Group: _____		
Personnel: _____		Plot Size (m <sup>2</sup> ): _____		Date: _____		
Station Coordinates: _____		Organization: _____				
Plant Community Type: _____ Freshwater _____ Intermediate _____ Brackish _____ Saline _____ Swamp						
Percent Cover: Total Cover* _____ % Shrub _____ % Herbaceous _____ % Carpet _____ %						
Average Height: Dominant Height _____ (cm) Shrub _____ (cm) Herbaceous _____ (cm) Carpet _____ (cm)						
Species List						
Present	Scientific Name	Common Name	% Cover	IN / OUT	Additional Species Description	
	B-B Rank: (5) 76-100%, (4) 51-75%, (3) 26-50%, (2) 6-25%, (1) 1-5%, (+) <1%, (r) Solitary					
	Ancillary Data: Photo(s) obtained (circle one): Yes / No ; camera stamp name: _____					
Dominant height of stems: ft / in / cm (1) _____; (2) _____; (3) _____; (4) _____; (5) _____						
Unvegetated Surface: Open water _____ % Bare ground _____ % Dead vegetation _____ % Flooded-Undetermined _____ %						
Water relative to marsh: _____ ft / in / cm. Above or Below (circle one) Floating Marsh? Yes / No						
Canopy Cover _____ % Tree Trunk Cover _____ %						
Notes (list tree species and tag numbers in plot and tree species out of plot):						

\*Total cover in swamp does not include trees > 5 cm dbh.

**Figure 7.2.** Herbaceous swamp vegetation sampling data sheet.

**Table 7.1.** Vegetative cover values associated with the Braun-Blanquet method.

Cover Range	Braun –Blanquet RankValue
Solitary(1)	r
<1(2)	+
1–5%	1
6–25%	2
26–50%	3
51–75%	4
79–100%	5

**REESTABLISHMENT:**

1. PVC pole is missing, stations should be reestablished as close to the original GPS coordinates as possible and a new PVC pole should be installed.
2. If a significant, unnatural anthropomorphic change to the study site has occurred (e.g., digging or dumping of soil at the site), the station should be reestablished using the next available random order number.

CPRA should be consulted on the establishment of new sites prior to reestablishment.

**CONVERSION OF STATIONS TO OPEN WATER:**

The intent of the CRMS monitoring program is to maintain the original monitoring stations for as long as possible. If the vegetation stations convert to open water, they will be maintained and data from the ten originally established stations will continue to be collected for the CRMS project life. Total cover will be recorded as 0% and water depth in the plot will be measured according to the sampling protocol. Stations may have to be re-established if they are disturbed by unnatural processes (are buried under a levee, etc...). CPRA will advise on how to proceed when stations are lost as needed.

**7.1.2 Data Processing**

The CPRA has implemented a two-phase protocol for data processing: data entry (Phase I) and quality assurance/quality control (Phase II). The two phases are conducted by separate individuals to assure that the final product is in 100% agreement with the data collected during the field sampling procedure.

**DATA ENTRY (PHASE I):** Phase I is conducted by the individual responsible for the field data collection. This individual is termed the “data collector.”

The data collector should complete the following procedures:



1. Verification of Field Samples: The samples collected in the field that were not positively identified must be examined by a qualified individual, such as a botanist or plant taxonomist. The plants shall be provided to the person as soon as possible before the integrity of the samples diminishes.
2. Review of Herbaceous Marsh or Swamp Vegetation Sampling Data Sheet
  6. Review the data sheet for completeness and accuracy.
  7. Examine the data sheet for the proper selection of each plant species. It is acceptable to use abbreviations for species in the field, but they should be defined in the office prior to delivery to the appropriate CPRA field office. Draw a single line through the name of the plant written in the field and write the correct name next to the misspelled or abbreviated name. Use the standard botanical names listed in the USDA Plants Database (<http://plants.usda.gov/>). Genus and species are sufficient. Changes must be accompanied by the data collector's initials and date.
3. Review of Porewater Data Sheet
  21. Review the data sheet for completeness and accuracy.
  22. Make corrections using a different color pen without erasing original data. If an error needs to be corrected, strike a single line through the error and write the changes close to the error.
  23. Accompany changes with the data collector's initials and date.
4. Data Transcription
  9. Enter the vegetation herbaceous data into an Excel spreadsheet in the appropriate format for SONRIS and save as a .csv file using the naming convention: "Station\_V\_YYYY-MM.csv". See Figure 7.3 for proper data format.
  10. Enter species' names into the data file using the complete name from the USDA Plants Database list, including the author's name (e.g., *Spartina patens* (Ait.) Muhl.).
  11. Enter the porewater data into an Excel spreadsheet in the appropriate format for SONRIS and save as a .csv file using the naming convention: "Station\_PW\_YYYY-MM.csv." See Figure 7.4 for proper data format.
  12. Save the photographs of the vegetation stations using the naming convention: "Station-VNN.jpg," where NN is the station name (spatially related, not the random number).
5. Data Verification
  - a. After data transcription is completed, double-check the files for accuracy.
  - b. Upon completion of the review of data, provide the electronic files to the QA/QC officer.

Once the data sheets have been corrected with respect to the unidentified and renamed plants, the data collector can begin the two-phase approach established by the CPRA to ensure the accuracy of the data.

**QUALITY ASSURANCE / QUALITY CONTROL (PHASE II):** Phase II begins when the QA/QC officer is provided the field data sheet and is notified that the .csv file has been completed. The QA/QC officer should follow the steps below to ensure the data have been processed properly. However, printing and completing the QA/QC Checklist (Figure 7.5) is not a requirement nor is it a deliverable.

The QA/QC officer should complete the following procedures:

7. Compare the .csv file to the field data sheet, checking for completeness and consistency.  
Note: CPRA has developed a SAS program that checks for logical inconsistencies in the vegetation data. Logical inconsistencies include those described in Section 7.1.1 “Methods.” The SAS program is available on the DNR FTP site or by request.
8. Compare the photographs of each station against the species list on the data sheet for accuracy and identification errors.
9. If mistakes are found, notify the data collector so they can be corrected.
10. Continue this process until no mistakes are found.

Once Phases I and II have been completed, upload the vegetation and porewater .csv files to the SONRIS buffer.

### 7.1.3 Deliverables

Electronic data files shall be in the appropriate deliverable format and delivered to CPRA once the data collector and QA/QC officer have completed the QA/QC process.

Deliverables should include the following:

10. Herbaceous Marsh or Swamp Vegetation Sampling Data Sheet (.pdf) (Figures 7.1 and 7.2)
11. Excel spreadsheet (.csv) of the herbaceous layer data (Figure 7.3)
12. Discrete Hydrographic/Soil Porewater Data Sheet (.pdf) (Figure 3.21)
13. Excel spreadsheet (.csv) of the porewater data (Figure 7.4)
14. Quality photographs of all herbaceous plots (.jpg)

## 7. Vegetation

Station ID	Group	Plot Size (m2)	Collection Date (mm/dd/yyyy)	Community	Sample Type	Vegetation Type	% Cover Total	% Cover Tree	% Cover Shrub	% Cover Herb	% Cover Carpet
CRMS0532-V02		4	7/30/2007	Intermediate	Transect	Natural	35			35	
CRMS0532-V02		4	7/30/2007	Intermediate	Transect	Natural	35			35	
CRMS0532-V02		4	7/30/2007	Intermediate	Transect	Natural	35			35	
CRMS0532-V02		4	7/30/2007	Intermediate	Transect	Natural	35			35	
CRMS0532-V02		4	7/30/2007	Intermediate	Transect	Natural	35			35	

(continued...)

Average Height Dominant (cm)	Average Height Tree (cm)	Average Height Shrub (cm)	Average Height Herb (cm)	Average Height Carpet (cm)	Scientific Name	Common Name	% Cover	Braun-Blanquet Rank	In/Out
85			45.7		Schoenoplectus americanus (P.)	OLNEY BULRUSH	10	2	Both
85			45.7		Lythrum lineare L.	WAND LYTHRUM	8	2	Both
85			45.7		Vicia lutea L.	smooth yellow vetch	12	2	Both
85			45.7		Symphyotrichum tenuifolium (L.)	perennial saltmarsh aster			Out
85			45.7		Spartina patens (Ait.) Muhl.	MARSHHAY CORDGRASS	15	2	Both

(continued...)

Number Planted	Number Alive	Additional Species Description	Organization	Personnel	Comments		
			COASTAL CONTRACTORS LLC	P. Boudreaux;T. Thibodeaux	Water Level is 0.01ft. Above Marsh		
			COASTAL CONTRACTORS LLC	P. Boudreaux;T. Thibodeaux	Water Level is 0.01ft. Above Marsh		
			COASTAL CONTRACTORS LLC	P. Boudreaux;T. Thibodeaux	Water Level is 0.01ft. Above Marsh		
			COASTAL CONTRACTORS LLC	P. Boudreaux;T. Thibodeaux	Water Level is 0.01ft. Above Marsh		
			COASTAL CONTRACTORS LLC	P. Boudreaux;T. Thibodeaux	Water Level is 0.01ft. Above Marsh		

**Figure 7.3.** Herbaceous vegetation data format.

## 7. Vegetation

Station ID	Date (mm/dd/yyyy)	Time (hh:mm)	Staff Gauge (ft)	Depth (ft)	Bottom Water Temperature (°C)	Surface Water Temperature (°C)	Bottom Specific Conductance (uS/cm)	Surface Specific Conductance (uS/cm)	Bottom Salinity (ppt)	Surface Salinity (ppt)
CRMS0532-V02	7/30/2007	8:50								
CRMS0532-V05	7/30/2007	9:01								
CRMS0532-V06	7/30/2007	9:20								

(continued...)

Bottom Dissolved Oxygen (milligrams/L)	Surface Dissolved Oxygen (milligrams/L)	Bottom pH (pH units)	Surface pH (pH units)	Bottom Velocity (ft/sec)	Surface Velocity (ft/sec)	Secchi (ft)	Fecal Coliform (MPN/100ml)	Soil Porewater Temperature at 30 cm (°C)	Soil Porewater Temperature at 10 cm (°C)
								29.3	30
								28	29
								26.5	27.6

(continued...)

Soil Porewater Temperature at 30 cm (°C)	Soil Porewater Temperature at 10 cm (°C)	Soil Porewater Specific Conductance at 30 cm (uS/cm)	Soil Porewater Specific Conductance at 10 cm (uS/cm)	Soil Porewater Salinity at 30cm (ppt)	Soil Porewater Salinity at 10cm (ppt)	Organization Name		
29.3	30	10830	9160	6.1	5.1	COASTAL CONTRACTORS LLC		
28	29	6010	6420	3.2	3.5	COASTAL CONTRACTORS LLC		
26.5	27.6	9880	7340	5.5	4	COASTAL CONTRACTORS LLC		

**Figure 7.4.** Soil porewater format at emergent vegetation stations.

<b>EMERGENT VEGETATION QA/QC CHECKLIST</b>		
Project / Site Number: _____ Date data collected: _____ QA officer: _____		
Data Collector: _____ Station Numbers (V18): _____		
DNR/USGS QA Officer: _____ Date Approved: _____		
		QA Officer's Initials and Date
1	Was a field trip report generated ? <b>Y / N</b> COMMENTS:	
2	Is comment section descriptive? <b>Y / N</b> COMMENTS:	
3	Were photos taken at each station and correctly labeled on dry erase board? <b>Y / N</b> COMMENTS:	
4	Were any stations re-established if so list stations? <b>Y / N</b> COMMENTS:	
5	Were porewater and surface water data collected at each station if not list stations? <b>Y / N</b> COMMENTS:	
6	Were all unknown vegetation species bagged labeled and sent to the botanist for identification? <b>Y / N</b> COMMENTS:	
7	Were data entered correctly into SONRIS? Were any data missing? <b>Y / N</b> COMMENTS:	
8	<b>Y / N</b> COMMENTS:	
9	<b>Y / N</b> COMMENTS:	
10	<b>Y / N</b> COMMENTS:	
11	<b>Y / N</b> COMMENTS:	
12	<b>Y / N</b> COMMENTS:	
13	<b>Y / N</b> COMMENTS:	
		Final QA Officer's Initials and Date

**Figure 7.5.** Emergent vegetation QA/QC checklist.

## 7.2 Swamp Forest

### 7.2.1 Site Design

The forest sampling design includes a combination of various-sized plots for measuring the canopy, understory (saplings and shrubs), and herbaceous layers of forested CRMS sites. All sampling will take place within three replicate 20 m x 20 m forest plots (i.e., stations). Nested within each of the larger forest stations will be three 6 m x 6 m understory stations, each containing one 2 m x 2 m herbaceous-layer station (Figure 7.6). At one CRMS site there will be a total of three forest stations, nine understory stations, and nine herbaceous vegetation stations that will be sampled.

The three forest stations are randomly selected from nine potential forest stations located every 30 m along the 283 m data collection area (DCA) diagonal transect (Figure 7.6). Vegetation transects are oriented across the DCA, either NW to SE or NE to SW, and are established away from spoil banks or any type of human-induced surface alterations to avoid biased data. Forest stations are named according to their spatial order, where station 1 is farthest north and station 9 is farthest south. The three forest stations are established based on their randomized order. CPRA will generate and provide the randomized station list, which includes the station numbers in their spatial (i.e., initial) order, coordinates for each station, and the randomly generated number for each station.

The three 6 m x 6 m understory stations will be located in the center and corners of the larger forest stations along the diagonal transect of each forest station (Figure 7.6).

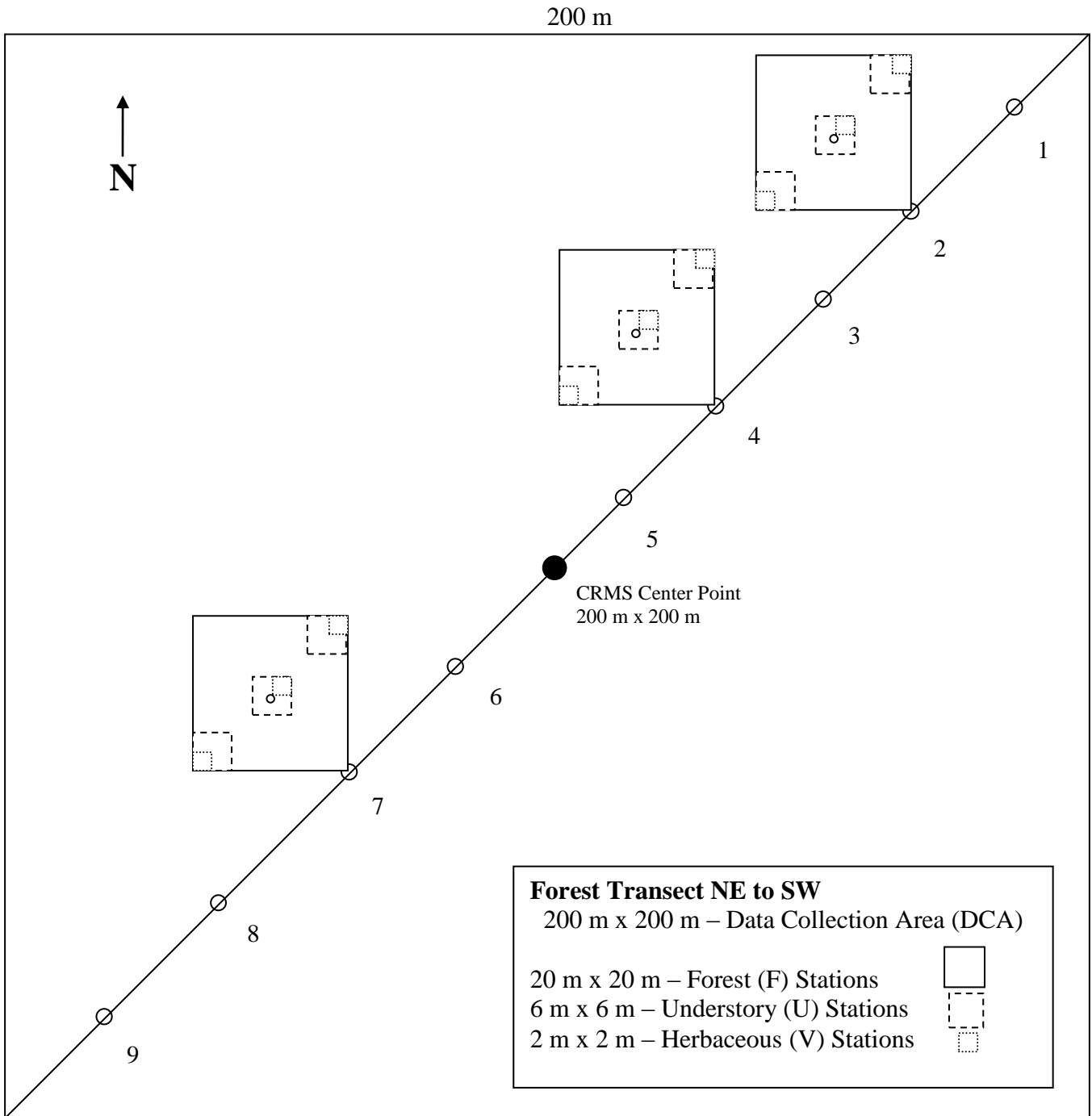
These transects should have the same orientation as the larger DCA station transects whenever possible. The three 2 m x 2 m herbaceous stations will be located in one corner of each understory station and oriented along the transect as well.

The naming convention for the swamp stations will be as follows (also see Figure 7.7):

Forest (F) Station (20 m x 20 m) = CRMS0000-F00, which is the CRMS site number followed by a hyphen (-), and ending with the forest station number. For example, CRMS0100-F03 would indicate CRMS site 100 and forest station 03.

Understory (U) Station (6 m x 6 m) = CRMS0000-F00UXX, which is the 1) CRMS site number, followed by 2) a hyphen (-), 3) forest station number 4) U for understory 5) orientation of understory within the forest station. Orientation choices include “C” for the center plot or the appropriate compass direction (NE NW, SE, SW) for the corner plots. For example, CRMS0100-F03UNW would indicate forest station CRMS0100-F03, and the understory station located in the northwest corner of the forest plot.

Herbaceous (V) Station (2 m x 2 m) = CRMS0000-F00VXX, which follows the same rules as applies to the understory stations, except a “V” is used instead of a “U.”



**Figure 7.6.** Illustration of swamp site design and layout (not to scale).

### 7.2.2 Field Station Establishment

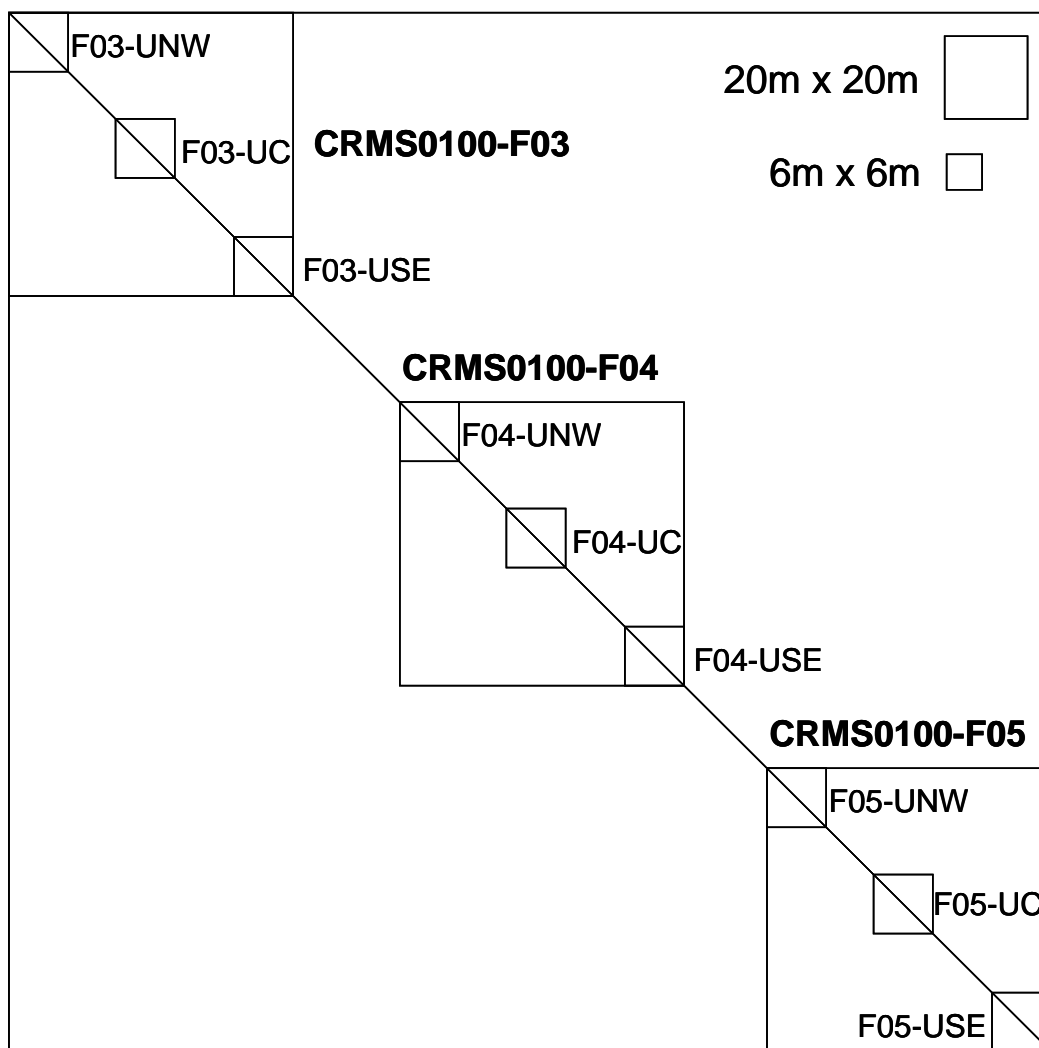
#### *Materials:*

In addition to the materials listed in Section 7.1.1, the following list of equipment and supplies is needed to establish and sample vegetation stations at forested CRMS sites. Some of these materials may not be needed in a given year, depending on the type of sampling being conducted. Other equipment and/or supplies may be needed depending on the site.

1. Metal pipes/rods: ½" diameter 3-ft galvanized coated or stainless steel rods used as permanent station markers in case of fires
2. Measuring tape/device: ½" fiberglass measuring tape capable of measuring 100 m
3. Canopy, understory, herbaceous, and porewater data sheets
4. Diameter tape: fabric tape used to measure the diameter of trees in metric (centimeters)
5. Calipers for measuring the diameter of trees and shrubs
6. Tree marking paint/chalk or flagging: used to mark trees that have been measured
7. Hammer, aluminum nails, and numbered tree tags: used to mark DBH measurements\
8. Aluminum ladder: used to aid in reaching DBH on some fluted trees
9. Densiometer
10. Densiometer stand
11. Loppers/cutters
12. PVC for corner plots
13. PVC marker caps
14. Protective clothing and gloves in case poison ivy is encountered

Field personnel should reference the randomized station list to determine the location of the first forest station. The first station located is the initial order number associated with random order number "1." The field crew should stay on the east side of the transect when it runs from NE to SW. Crews can access transects that run from NW to SE from either side but should provide a minimum buffer of 10 m between the access route and the station. Once the station is located, a PVC pole should be installed at the station coordinate, marking the southeast corner of the forest plot. The outline of the 20 m x 20 m quadrant should then be measured and its corners marked with PVC poles so that the marker pole is the southeast corner of the plot and that one side is facing due north. If the plot is ≥55% land, the plot will be selected and sampled. If the plot is <55% land, the plot will not be used and the crew will replace it with the next random order number. This process will be repeated until all three stations are established. After the three forest sites have been established and selected, the smaller substations (i.e., understory and herbaceous) should be delineated and their corners marked with PVC poles.





**Figure 7.7.** Illustration of the naming convention for swamp stations and their nested understory stations.

**CONVERSION TO OPEN WATER:**

The intent of the CRMS monitoring program is to maintain the original monitoring stations for as long as possible. If the forested vegetation stations convert to open water, they will be maintained and data from the originally established stations will continue to be collected for the CRMS project life. Total cover will be recorded as 0% and water depth in the plot will be measured according to the sampling protocol. CPRA will advise on how to proceed when stations are lost as needed.

**7.2.3 Field Methods**

Forest vegetation sampling shall occur during the 12-week period between August 1 and October 31. Some landowners limit access to sites in October due to deer hunting activities; therefore, sites with this restriction must be sampled in August and September. In addition to the methods described in this section, soil cores shall be taken every six years in conjunction with swamp sampling. Soil sampling methods are described in Section 8.

**7.2.3.1 *Canopy Layer*****► *Species composition and tree diameters:***

Sampling methods described in this section shall be performed every three years, starting in 2009 (i.e., 2009, 2012, 2015,...). Within each of the three 20 m x 20 m stations at each CRMS site, trees  $\geq 5$  cm DBH will be identified to the species level, tagged and numbered, and measured at the appropriate height. These data will be recorded on the data sheet titled *Forest Community Data Sheet - Canopy Layer* (Figure 7.8). Diameter at breast height is defined as tree diameter at 4.5 ft above ground as measured from the uphill side of the stem. Measurements of irregular tree stems shall follow the methods prescribed in Avery and Burkhart (1994), part of which is described below. Because DBH measurements will be replicated in the future, tree tags will be nailed at the location where the DBH was measured on all trees, including those with irregular stems. During sampling, trees may be temporarily marked with chalk or paint or flagging to assure that each tree has been accounted for and measured, as well as to prevent a tree from being measured twice.

The following procedures shall be used to measure DBH of trees with irregular stems [reference pages 144–149 in Avery and Burkhart (1994)]:

5. If a tree stem is forked immediately above breast height (4.5 ft), it shall be measured below the swell resulting from the double stem. This change in procedure shall be noted on the data sheet by marking that the DBH was “shifted,” and the height above ground that the diameter measurement was taken shall be recorded in the appropriate column (Figure 7.8).

6. If the tree stem is forked below breast height, then each stem is considered to be two separate trees. The diameter of each stem shall be measured at 3.5 ft above the fork and each tree shall be marked with a numbered tag. This change shall be noted on the data sheet as described above.
7. If the tree has a buttress or fluted bole (e.g., tupelo or cypress) and the buttress is greater than 3 ft high, DBH shall be measured at 1.5 ft above the point where the buttress swell stops noticeably tapering. This change shall also be noted on the data sheet as described above.

### ► **Canopy cover (*densiometer*):**

Canopy cover shall be determined every year starting in 2012. A convex densiometer shall be used to measure % canopy cover in each of the four cardinal directions (N, E, S, W) from the center of each of the three 20 m x 20 m forest stations per CRMS site.

#### *Materials:*

1. One 2" schedule 40 PVC pipe, 4 ft long
2. 4" x 4" square plate
3. Convex spherical densitometer
4. Calculator
5. Rubber bands, blue tac, double sided tape, etc.

To standardize the height at which densiometer readings are taken and to aid in stabilizing the instrument, a densiometer stand shall be constructed and used during data collection. To construct the stand, cut the 4-ft PVC pipe so that both ends are square. The 4" plate shall be centered and permanently affixed to one end of the pipe. This stand design will allow the spherical densiometer to be placed on the plate and secured by two rubber bands or a similar securing device.

## 7. Vegetation

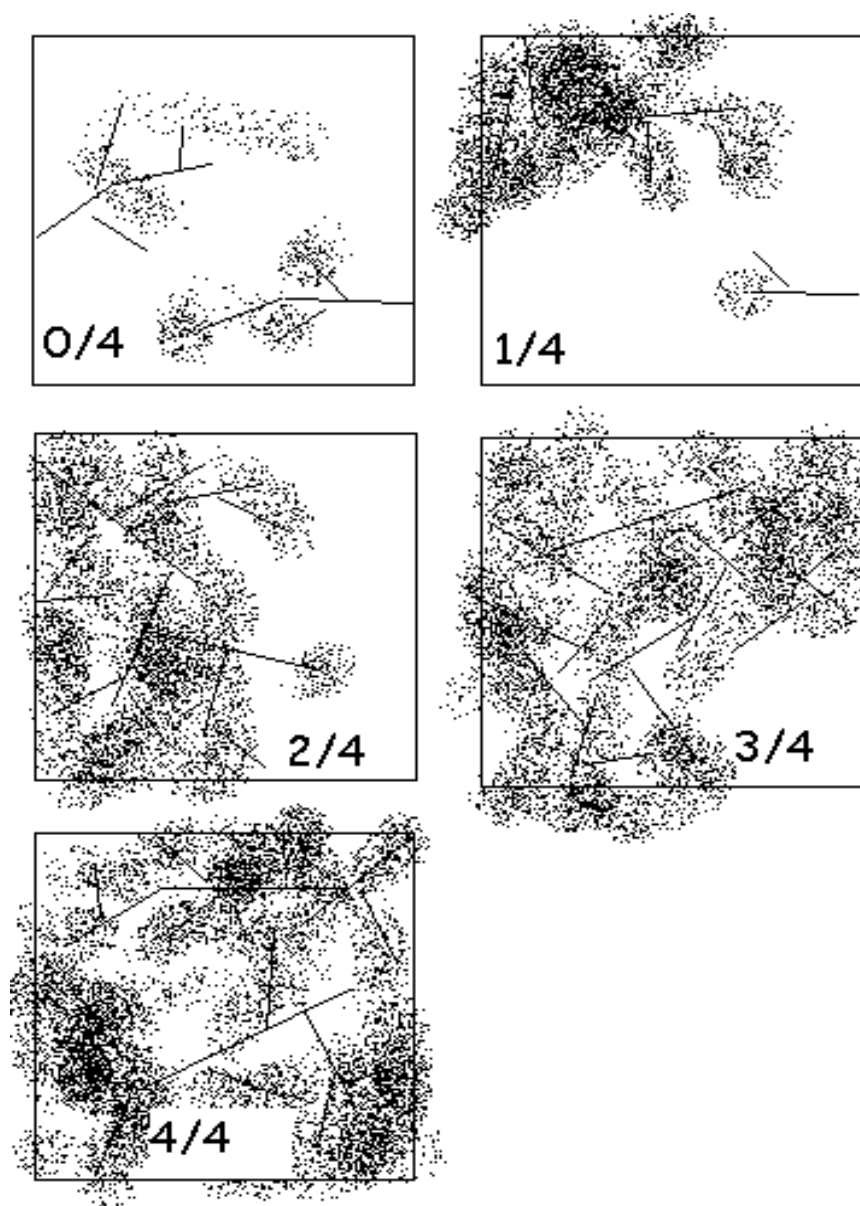
[illegible]

**Figure 7.8.** Field data sheet for the canopy layer data, which include species composition, tree diameter measurements, and densiometer measures.

Measurements shall be taken as close to the center of the 20 m x 20 m plots as possible. However, if it is not feasible to stand in the exact center, the closest possible location will be used as long as it is within the 20 m x 20 m plot and not within either of the 2 m x 2 m herbaceous vegetation plots. The data collector should place the base of the densiometer stand firmly on the ground so that the 4" plate is on top and close to level. Next, the densiometer should be centered and secured to the top of the plate. The bubble level in the densiometer should be on the side closest to the data collector. The data collector should stand approximately half an arm's reach away from the pole so that he or she casts no reflection in the mirror. He or she should also check and make sure that no other human-made structure is casting a reflection. If this is not the case, the item/structure should be moved prior to data collection. Finally, the data collector should make sure the bubble level is centered before taking any readings on the densiometer.

Once the densiometer is positioned correctly, the % canopy cover shall be read. The convex mirrored surface is etched with 24 squares in a grid pattern. Each of these squares should be viewed as if subdivided into four smaller squares, resulting in a total of 96 subsquares. Beginning at the top left of the grid, look at the first square and determine how many of its four subsquares are dominated by canopy cover. If a subsquare is dominated by canopy, it is given a value of "1." If it is not dominated by canopy, it is given a value of "0." Figure 7.9 demonstrates examples of cover percentages in one of the 24-grid squares of the spherical densiometer. A value of 0–4 should be determined for each square. Continue moving in a systematic fashion until all 24 squares, hence all 96 subsquares, have been counted to provide a number from 0 to 96. Multiply that number by 1.04 and round to the nearest whole number to calculate % cover of forest canopy. An alternative method for counting cover in locations with heavy cover is as follows: if your site has more than 50% cover, count the number of subsquares without cover (i.e., light penetration or sky) and subtract that number from 96, then multiply the result by 1.04.

To ensure consistency and eliminate some of the inherent variability in reading canopy cover, a minimum of two (preferably three) field personnel should calculate % canopy cover at the same site within a few minutes of each other (so as to eliminate time effects). These results should be averaged for the final recorded result. If the difference between any two of the readings is more than 25%, all field personnel should retake their readings and/or discuss differences of interpretation until a consensus is reached. Densiometer data shall be recorded on the data sheet titled *Forest Community Data Sheet-Canopy Layer* (Figure 7.8).



**Figure 7.9.** Examples of proper values given to canopy cover in one square of the densiometer. Each square of the densiometer is divided into four subsquares. If a subsquare is dominated by canopy cover it is given a value of 1; therefore, each square can have a maximum value of 4.

### **7.2.3.2 Understory Layer**

Sampling of the understory layer shall be completed every three years starting in 2009 (i.e., 2009, 2012, 2015...) and sampled in conjunction with the canopy layer sampling described in Section 7.2.3.1. Three 6 m x 6 m plots nested within each of the three 20 m x 20 m stations at each CRMS site will be sampled for a total of nine understory-layer plots per CRMS site (see Figure 7.6).

#### *Materials:*

1. DBH tape or calipers
2. 4 Meter Telescopic leveling rod and meter stick

Within each plot, all woody shrubs and trees (saplings and seedlings) < 5 cm DBH will be identified to the species level, counted, and their height measured. Diameter at breast height measurements shall be taken for shrubs and saplings of adequate height. For multiple-stemmed shrubs, DBH values will be measured and averaged on three representative stems. In addition, the total number of stems will be counted and recorded. For saplings with irregular stems, the procedures of Avery and Burkhart (1994) should be followed. All data will be recorded on the data sheet titled *Forest Community Data Sheet -Understory Layer* (Figure 7.10).

### **7.2.3.3 Herbaceous Layer**

Sampling for the swamp herbaceous layer shall be conducted annually. Furthermore, this sampling shall be done in conjunction with the tree-layer sampling conducted every third year. Nine nested 2 m x 2 m plots will be sampled from each CRMS site (Figure 7.6). The methods, data sheets, QA/QC, and deliverables for swamp herbaceous sampling will be the same as described in Section 7.1.

## 7. Vegetation

[illegible]

**Figure 7.10.** Field data sheet for the understory layer, which includes woody shrubs and sapling trees < 5 cm diameter at breast height.



### 7.2.4 Data Processing

The CPRA has implemented a two-phase protocol for data processing: data entry (Phase I) and quality assurance/quality control (Phase II). The two phases are conducted by separate individuals to assure that the final product is in 100% agreement with the data collected during the field sampling procedure.

**DATA ENTRY (PHASE I):** Phase I is conducted by the individual responsible for the field data collection. This individual is termed the “data collector.”

The data collector should complete the following procedures:

11. Verification of Field Samples: The samples collected in the field that were not positively identified must be examined by a qualified individual, such as a botanist or plant taxonomist. The plants shall be identified as soon as possible before the integrity of the samples diminishes.
12. Review of Vegetation Sampling Data Sheets
  - a. Review the canopy, understory, and herbaceous layer data sheets for completeness and accuracy.
  - b. Examine the data sheets for the proper selection of each plant species. It is acceptable to use abbreviations for species in the field, but they should be defined in the office prior to delivery to the appropriate CPRA office. Draw a single line through the name of the plant written in the field and write the correct name next to the misspelled or abbreviated name. Use the standard botanical names listed in the USDA Plants Database (<http://plants.usda.gov/>). Genus and species are sufficient. Changes must be accompanied by the data collector’s initials and date.
13. Review of Porewater Data Sheets
  - a. Review the data sheets for completeness and accuracy.
  - b. Make corrections using a different color pen without erasing original data. If an error needs to be corrected, strike a single line through the error and write the changes close to the error.
  - c. Accompany changes with the data collector’s initials and date.
14. Data Transcription
  - I. Enter the data from each of the vegetation layers into Excel spreadsheets in the appropriate format for SONRIS. Follow the column order and formatting given in Figures 7.1 and 7.2 (herbaceous layer data), Figure 7.11 (forest canopy and understory layer data), and. Canopy and understory data are collected on separate data sheets but are uploaded and stored together in the database. Save the spreadsheets as .csv files using the following naming convention: “*Station\_X\_YYYY-MM.csv*,” where “X” will be one of the following: 1) “forest” for the canopy and

understory layer data, and 2) “herbaceous” for herbaceous layer data (ex. CRMS0008\_forest\_2011-10. Note: These files will contain the entire set of stations for each data type for each site (e.g., three “F” stations, nine “U” stations, and nine “V” stations).

- m. Enter species’ names into the data file using the complete name from the USDA Plants Database list, including the author’s name (e.g., *Spartina patens* (Ait.) Muhl.).
- c. Enter the porewater data into an Excel spreadsheet in the appropriate format for SONRIS (Figure 7.4) and save as a .csv file using the naming convention “Station\_PW\_YYYY-MM.csv.”
- d. Save the photographs of the herbaceous vegetation stations using the naming convention “Station-F00VXX.jpg.” See section 7.2.1 for an explanation of the naming convention.

#### 15. Data Verification

- a. After data transcription is completed, double-check the files for accuracy.
- b. Upon completion of the review of data, provide the electronic files to the QA/QC officer.

Once the data sheets have been corrected with respect to the unidentified and renamed plants, the data collector can begin the two-phase approach established by the CPRA to ensure the accuracy of the data.

**QUALITY ASSURANCE/QUALITY CONTROL (PHASE II):** Phase II begins when the QA/QC officer is provided the field data sheets and is notified that the .csv files have been completed. The QA/QC officer should follow the steps below to ensure the data have been processed properly. However, printing and completing the QA/QC Checklist (Figure 7.5) is not a requirement nor is it a deliverable.

The QA/QC officer should complete the following procedures:

1. Compare the .csv file to the field data sheet, checking for completeness and consistency.  
Note: The CPRA has developed a SAS program that checks for logical inconsistencies in the herbaceous vegetation data. Logical inconsistencies include those described in Section 7.1.1 “Methods.” The SAS program is available on the DNR FTP site or by request.
2. Compare the photographs of each station against the species list on the data sheet for accuracy and identification errors.
3. If mistakes are found, notify the data collector so mistakes can be corrected.
4. Continue this process until no mistakes are found.

Once Phases I and II have been completed, upload the vegetation and porewater .csv files to the SONRIS buffer.

### 7.2.5 Deliverables

Electronic data files shall be in the appropriate deliverable format and delivered to CPRA once the data collector and QA/QC officer have completed the QA/QC process.

Canopy Layer:

1. *Forest Community Data Sheet-Canopy Layer* (.pdf) (Figure 7.8)
2. Excel spreadsheet (.csv) including the canopy layer data (Figure 7.11)

Understory Layer:

1. *Forest Community Data Sheet-Understory Layer* (.pdf) (Figure 7.10)
2. Excel spreadsheet (.csv) including the understory layer data (Figure 7.11)

Herbaceous Layer:

1. *Herbaceous Marsh or Swamp Vegetation Sampling Data Sheet* (.pdf) (Figures 7.1 and 7.2)
2. Excel spreadsheet (.csv) of the herbaceous layer data (Figure 7.3)
3. *Discrete Hydrographic/Soil Porewater Data Sheet* (.pdf) (Figure 7.4)
4. Excel spreadsheet (.csv) of the porewater data (Figure 3.24)
5. Quality photographs of all herbaceous (2 m x 2 m) plots (.jpg)

## 7. Vegetation

Station ID	Forest Layer	Group	Plot Size (m2)	Collection Date (mm/dd/yyyy)	Community	Sample Type	Densiometer Reading - North	Densiometer Reading - South	Densiometer Reading - East
CRMS0046-F04UNE	Understory		6	9/10/2009	Swamp	Transect			
CRMS0046-F04UNE	Understory		6	9/10/2009	Swamp	Transect			
CRMS0046-F04UNE	Understory		6	9/10/2009	Swamp	Transect			
CRMS0046-F04	Overstory		400	9/21/2009	Swamp	Transect	9	8	13
CRMS0046-F04	Overstory		400	9/21/2009	Swamp	Transect	9	8	13
CRMS0046-F04	Overstory		400	9/21/2009	Swamp	Transect	9	8	13
CRMS0046-F04	Overstory		400	9/21/2009	Swamp	Transect	9	8	13

Densiometer Reading - West	Average Densiometer Reading	Canopy Cover (%)	Tree Number	Scientific Name As Originally Observed	Common Name As Originally Observed	Scientific Name As Currently Recognized
				Acer rubrum L.	RED MAPLE	Acer rubrum L.
				Acer rubrum L.	RED MAPLE	Acer rubrum L.
				Ilex verticillata (L.) Gray	common winterberry	Ilex verticillata (L.) Gray
3	8.25	91.42	123	Fraxinus caroliniana P. Mill.	Carolina ash	Fraxinus caroliniana P. Mill.
3	8.25	91.42	124	Nyssa aquatica L.	water tupelo	Nyssa aquatica L.
3	8.25	91.42	127	Fraxinus caroliniana P. Mill.	Carolina ash	Fraxinus caroliniana P. Mill.
3	8.25	91.42	128	Fraxinus caroliniana P. Mill.	Carolina ash	Fraxinus caroliniana P. Mill.

Common Name As Currently Recognized	Understory Layer Growth Form	Overstory Layer Tree Diameter (cm)	Overstory Tree DBH Distance Aboveground (cm)	Total Number of Stems	Understory Plant Diameter (cm) At Breast Height 1
RED MAPLE	Single Stem			1	3
RED MAPLE	Single Stem			1	2.4
common winterberry	Single Stem			1	0.6
Carolina ash		7.8			
water tupelo		37.3			
Carolina ash		6.7			
Carolina ash		6			

Understory Plant Diameter (cm) At Breast Height 2	Understory Plant Diameter (cm) At Breast Height 3	Understory Plant Height (cm)	Additional Species Description	Organization
		15		CONTRACTOR ABC
		13.5		CONTRACTOR ABC
		4.5		CONTRACTOR ABC
				CONTRACTOR ABC
				CONTRACTOR ABC
				CONTRACTOR ABC
				CONTRACTOR ABC

Personnel	Comments
P. Boudreaux; T. Thibodeaux	
P. Boudreaux; T. Thibodeaux	
P. Boudreaux; T. Thibodeaux	
P. Boudreaux; T. Thibodeaux	Water Level is 0.35 ft above marsh.
P. Boudreaux; T. Thibodeaux	Water Level is 0.35 ft above marsh.
P. Boudreaux; T. Thibodeaux	Water Level is 0.35 ft above marsh.
P. Boudreaux; T. Thibodeaux	Water Level is 0.35 ft above marsh.

**Figure 7.11.** Forest canopy and understory layer data format.

## 8. SOIL PROPERTIES

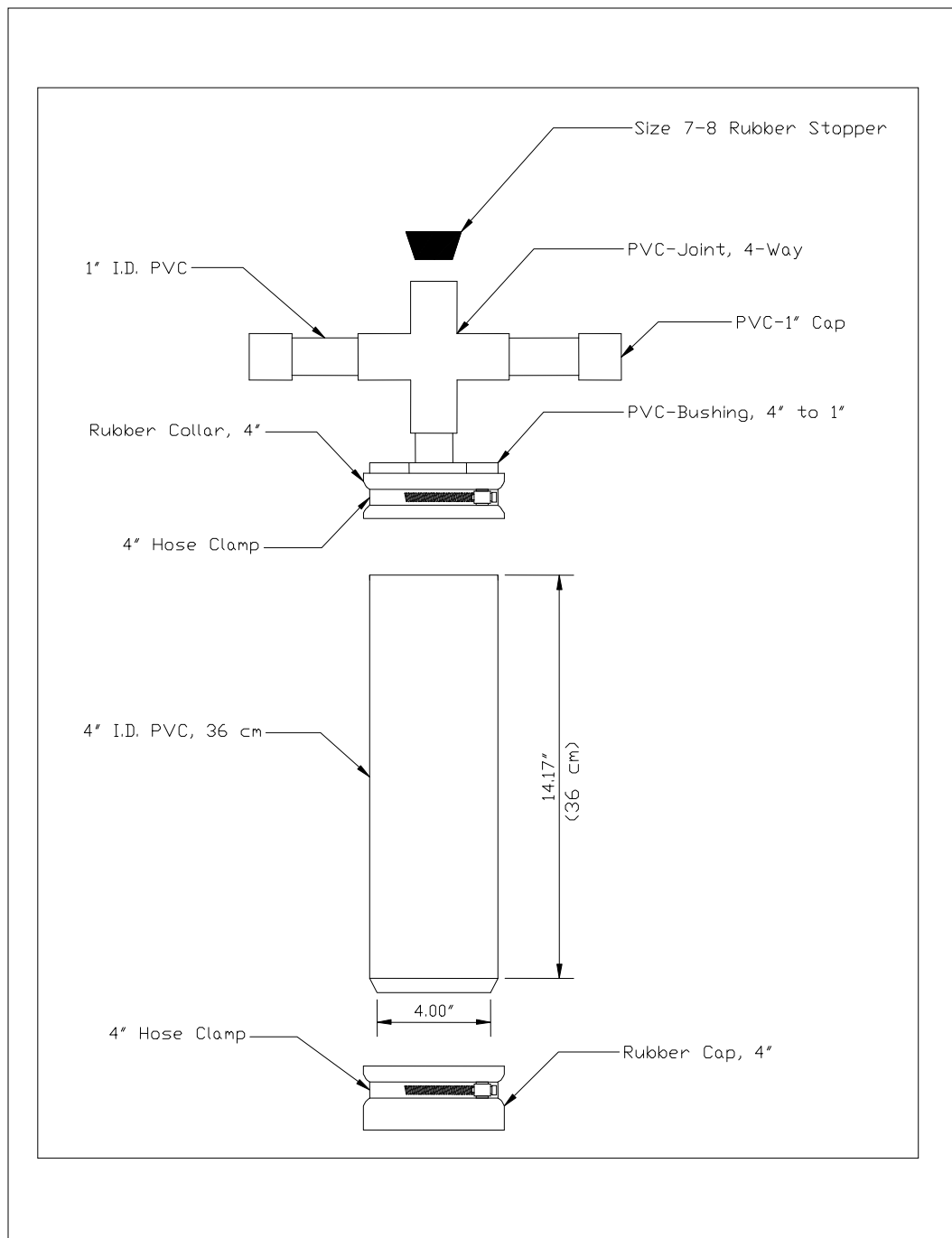
The soil properties of concern to the CPRA include but are not limited to soil pH, soil salinity (EC), bulk density, soil moisture, percent organic matter (loss-on-ignition or LOI), and wet/dry volume. Soil pH is determined through a standardized procedure on both wet and dry soils. The average of replicate samples for both saturated and dry pH measurements, which is reported for each sample as the ratio of wet saturated and dry soil pH, indicates the potential for pyrite formation. Soil salinity is determined by laboratory measurements of a saturated sample's electrical conductivity (Brady and Weil 2002). The average of replicate samples for electrical conductivity is reported in both mS/cm and ppt. Bulk density is defined as the total weight of material—both organic and inorganic fractions—in a known volume of sample, and is given in units of grams per cubic centimeter ( $\text{g}/\text{cm}^3$ ). Bulk density of organic wetland soils can be as low as  $0.01 \text{ g}/\text{cm}^3$  but it is commonly around 0.2 to  $0.3 \text{ g}/\text{cm}^3$ . In mineral soils in wetlands, bulk density can be as low as  $0.5 \text{ g}/\text{cm}^3$ , but it is usually between 1 and  $2 \text{ g}/\text{cm}^3$ . Soil density in wetland soils is controlled by the amount of mineral material that infiltrates the organic material framework in highly organic marsh soils. Soil moisture will be determined through the drying process for bulk density and is calculated as a percentage from the wet and dry sample weight. Percent organic matter is determined by the amount of weight loss upon ignition at  $550^\circ\text{C}$  (Andrejko et al. 1983). Soils composed completely of organic matter will lose 100% of sample matter on ignition. Both wet and dry volume of each sample will be determined and the ratio of wet to dry volume will be calculated. The wet/dry volume ratio provides the potential for linear compaction for each sample.

Several core extraction devices have been designed for use in wetlands. The ideal core tube is sharpened on the bottom so that the root mat can be cut as the core tube is slowly inserted. A clear core tube may also be beneficial as any compaction can be identified before the core is fully extracted and adjustments can be made. Many corers have been designed to facilitate the process of extracting cores with the least amount of marsh disturbance and compaction (e.g., Swenson 1982, Hargis and Twilley 1994, Meriwether et al. 1996). Any combination of core tube materials and caps may be used to obtain cores as situations require, as long as the inside diameter of the tube is 4" and cores can be sliced into 1.57" (4-cm) increments in the field. As minimizing the compaction of soil inside the core tube and reducing damage to the marsh are paramount, the CPRA suggests the use of a Meriwether corer (Meriwether et al. 1996) to collect 30-cm-deep cores (Figure 8.1). This corer has been documented to work well in saturated and semi-saturated salt and brackish marsh soils. Field personnel shall determine the best core extraction method to use in each situation.

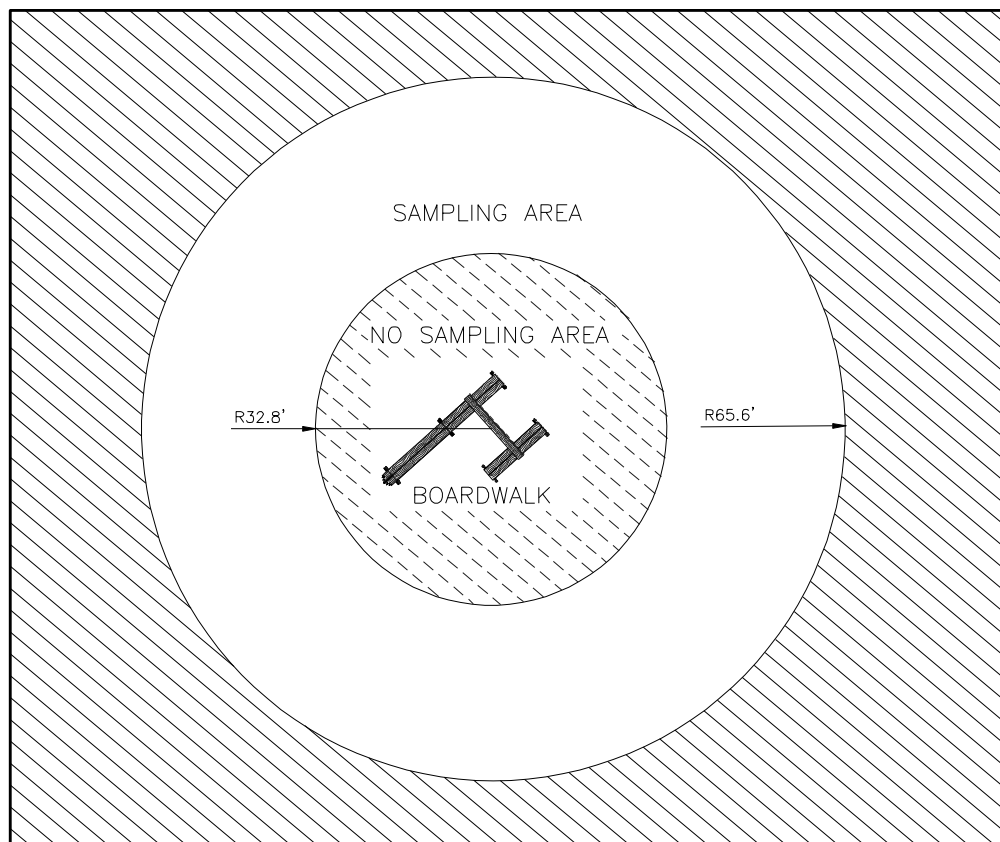
### 8.1 Field Station Establishment

Baseline soil samples shall be collected from all sites within one year of site establishment. In addition to the baseline cores, soils shall be sampled every 10 years for marsh sites and every six years for swamp sites. Cores will be taken 10–20 m away

from the CRMS boardwalk and at least 10 m from other CRMS sampling stations (Figure 8.2). Cores will be taken in the same marsh type as is represented by the CRMS DCA. Cores will be taken on a surface that is representative of the area (i.e., not on obvious high or low points, on clumps, or in trenasses).



**Figure 8.1.** Typical specifications of a core extracting device (modified from Meriwether et al. 1996 and Phillips 2002).



**Figure 8.2.** Diagram of CRMS site boardwalk area and the area available for sediment sample collection. Field personnel shall not collect soil cores or step within the 32.8-ft (10-m) buffer around the boardwalk. Soil samples shall be collected within 65.6 ft (20 m) from the boardwalk. Note: Potential future vegetation stations should be avoided.

Every attempt shall be made to take cores on a similar surface in each Visser marsh type (Visser and Sasser 1998) (e.g., between culms of grass in *Spartina patens* dominated marsh). Cores will be taken at least 16.4 ft (5 m) from each other. A detailed guide to determining where soil cores should be taken can be found below in Section 8.2 (Data Collection, Procedures). Care should be taken not to damage the marsh when extracting/extruding cores (e.g., utilizing a platform such as a plywood sheet on the marsh) and that core locations do not interfere with future monitoring activities such as vegetation monitoring.

### 8.2 Data Collection

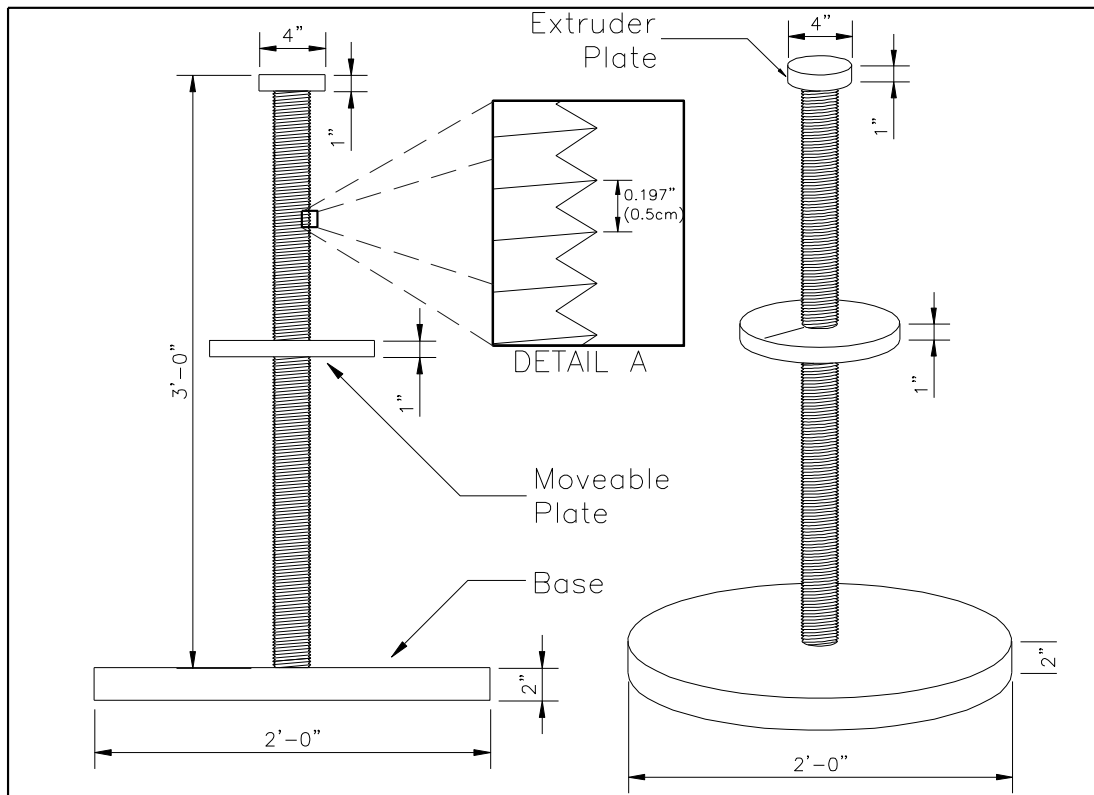
Soil cores shall be collected carefully to obtain a known volume of soil with little to no compaction of the soil matrix. Field personnel will collect three (3) soil cores with an inside diameter of 4" (10.2 cm) to a depth of 11.8" (30.0 cm) from each CRMS-Wetlands site. Cores will be extruded in the field using a precise core-extruding device (Figure 8.3) and sliced in the field into 1.57" (4-cm) increments to a depth of 9.45" (24 cm). The remainder of the core is discarded after the total depth of the core is determined by extrusion and recorded in the appropriate space on the soil cores data sheet (Figure 8.4). Core samples will be placed on ice immediately after collection and delivered to the contracted soils lab in labeled storage bags (or containers) along with the chain of custody form (Figure 8.5). The CPRA recommends the use of Glad® quart and gallon size storage bags as they can withstand an oven temperature of 140°F (60°C) for several days and will not melt during the sample drying process in the lab. A copy of the soil cores data sheet will be provided to the CPRA within one week of soil core collection.

The Meriwether corer includes a coring handle constructed of PVC with rubber attached to the top of the core tube. The handle is attached to the core tube and the tube is slowly inserted into the soil to a depth of 30 cm, slowly cutting through the root zone by turning the core tube as it is inserted. Measurements of the depth of insertion from the top of the core tube to the soil surface both inside and outside of the core tube are then made and recorded in the correct spaces on the soil cores data sheet (Figure 8.4). Note that the Meriwether coring handle must be removed to make these measurements. The head space in the top of the core and handle is filled with water from the nearest source and is stoppered to create a seal. The core is then slowly pulled from the marsh surface and a rubber cap is placed on the bottom of the core as it emerges. The Meriwether corer facilitates core extraction without digging or losing core material from the bottom of the core. It may be necessary to cut the root zone as the core tube is inserted and to use clear core tubes to help reduce compaction.

Some sites may have soils that are too fluid or unconsolidated to extrude and slice with any precision. Two (2) attempts will be made to obtain cores that can be sliced. If cores cannot be sliced, three (3) cores shall be collected from those sites to a depth of 5.9" (16 cm) using a 4" (10.2-cm) diameter core tube



sharpened on the end. For the 5.9" (16-cm) deep, unsliced samples, a large stopper or cap should be placed over the top of a 5.9" (16-cm) core tube. A sharpened aluminum tube may be best for this application. The handle is not necessary for the shallow sediments. The top of the core should then be stoppered or capped and the core should be extracted by hand and quickly capped on the bottom.



**Figure 8.3.** Typical construction diagram for the soil core extruder (redrawn from Phillips 2002). The 4-in. extruder plate fits tightly inside the core tube. A moveable plate (diameter typically ~6-8") moves up or down the lead screw with a precise pitch of 0.197" (0.5 cm) per one revolution. The extruder is constructed of PVC and custom machined.

## 8. Soil Properties

[illegible]

**Figure 8.4.** Soil cores data sheet.

## 8. Soil Properties

[illegible]

**Figure 8.5.** Chain of custody form.

Problems will be encountered from site to site. There may be better core sampling conditions on some days than others. At each CRMS site, the best coring method should be determined and utilized. Refer to the detailed procedures provided below. Detailed notes should be recorded in the given blanks on the soil cores data sheet (Figure 8.4). The entire 5.9" (16-cm) core sample (including interstitial water) should be placed on ice in a labeled gallon-sized Glad® storage bag (or other container) and delivered to the contracted soils lab.

### *Field Materials:*

5. Three (3) sharpened 4" (10.2-cm) inside-diameter core tubes at least 11.8" (30 cm) long. Core tubes can be acrylic, aluminum, or PVC. Tubes 14.2" (36 cm) long are recommended as the rubber boot on the Meriwether corer covers 2.4" (6 cm) of the core tube.
6. Sharpened 4" (10.2-cm) inside-diameter core tube exactly 5.9" (16 cm) long or with 5.9" (16 cm) from bottom clearly marked/etched on the core tube
7. PVC Meriwether corer with rubber boot
8. Carboy, or other container, for transporting water from nearest source to coring site, for use with Meriwether corer
9. Rubber stopper to fit top PVC opening of Meriwether corer (size 7–8)
10. Six (6) 4" (10.2-cm) rubber core end caps with tightening bands
11. Nut driver that fits tightening bands (0.5")
12. Large rubber stopper or cap (large enough to fit in 4" (10.2-cm) core tube)
13. Soil core extruder with 4" (10.2-cm) extruder plate attached; machined to 0.5 cm per revolution
14. Serrated knife (at least 6" long) for core slicing and root zone slicing
15. Sheet of plywood (~4-ft x 4-ft)
16. Eighteen (18) labeled Glad® quart sample storage bags. Label should include CRMS-*Wetlands* site number, core number, and sample depth (i.e., 0–4 cm, 4–8 cm, etc.). An additional three (3) large, labeled storage bags to be used for 16-cm cores if soils are too fluid to extrude and slice.
17. Additional storage bags large enough to hold all five samples from each core
18. Ice chest and ice for sample storage and transportation
19. Soil cores data sheet (Figure 8.4)
20. Chain of custody form (Figure 8.5)

### *Procedures:*

The following section describes the procedure for identifying the location for soil core collection at each CRMS site and for collecting the core samples.

Soil Core Decision Tree and Extraction Protocol:

1. Core samples shall be collected outside of a 32.8-ft (10-m) radius but within a 65.6-ft (20-m) radius of the sampling platform and at least 32.8 ft (10 m) from any other sampling plot. Are you within this zone? If yes, go to the next step. If no, relocate core sampling area.
2. Are you in an area/vegetation type representative of the 200 m x 200-m plot? If yes, go to the next step. If no, relocate and go to step 1.
3. Are you away from any obvious high or low spots? If yes, go to the next step. If no, relocate and go to step 1.
4. If this is the second or third core, are you at least 16.4 ft (5 m) from the previous core location? If yes, go to the next step. If no, relocate and go to step 1.
5. Take 11.8" (30-cm) core.
6. To collect the core sample, use a 4" (10.2-cm) inside-diameter sharpened core tube (Figure 8.1). Sharpened clear acrylic, thin-walled aluminum, or PVC core tubes may be utilized.
7. Slowly depress the core tube into the sediment using a rotating/twisting motion to assist in cutting root and peat material in order to minimize compaction. Unless the core tube is sharp enough to easily penetrate the soil and root/peat material, it may be necessary to cut around the base of the core tube straight up and down with a serrated knife through the root zone before inserting the core tube into the soil.
8. Depress the core tube to 30 cm depth or greater while continuing to rotate/twist the tube. Take care not to compact/compress the soil inside the tube.
9. To document compaction, measure the distance to the sediment surface on the outside and inside of the core tube. Measurements should be made at the same place on the outside and inside of the core tube to avoid differences in ground height caused by uneven surfaces or vegetation density. If using the Meriwether corer, the cap should be removed or measurements should be taken through the cap before the cork is inserted, as best as possible given the soil consistency.
10. Record both measurements on the soil cores data sheet (Figure 8.4).
11. Core compaction should be 10% or less (i.e., < 3 cm for a 30-cm core) in most soil types. Highly organic soils (e.g., floating marsh, flooded swamp sites) may have a compaction rate of up to 20%. All caution should be taken to obtain cores with a minimal amount of compaction.
12. Plug or cap the top of the core tube to assure suction, filling the head space with water from the immediate area if using the Meriwether corer. If the soils are not saturated, no water should be added to the head space.
13. Remove the core from the marsh and quickly cap the bottom of the core tube to avoid loss of material.
14. Remove the bottom cap from the core tube and place the core tube on the core extruder.

15. Remove the stopper from the Meriwether corer to break the seal and remove the coring handle.
16. Position the core extruder plate so the surface of the soil core is at the top of the core tube.
17. Is the soil core solid enough to extrude and slice? If yes, go to the next step. If no, discard the soil core material away from all sampling areas and go back to step 5 above and take a second core. If the second core attempt results in a core too fluid to be sliced, go to step 22 below.
18. Extrude the top 4 cm of the soil core (0–4 cm), carefully slice, and place in a pre-labeled Glad® bag or other airtight container. This container will be used in the laboratory during the drying process and will be heated to 60°C (140°F). It must be able to be heated to this temperature without melting, changing composition, or reacting with the sample. Any sample remaining on the knife should be included with the sample.
19. Repeat for remaining intervals (4–8, 8–12, 12–16, 16–20, 20–24 cm).
20. Repeat until three (3) viable cores have been taken and processed.
21. Place all soil samples on ice and transport back to the lab.
22. If the soil core is too fluid to be sliced (determined in step 17, above), take a 16-cm core using the following protocol (steps 23–33).
23. Use a 4" inside-diameter sharpened clear acrylic, thin-walled aluminum, or PVC core tube. The Meriwether corer should not be used for this application. The core should be capped/stoppered and dug out, while supporting the bottom with a core cap as described below (steps 29–30).
24. Slowly depress the core tube into the sediment using a rotating/twisting motion to assist in cutting root and peat material in order to minimize compaction. Unless the core tube is sharp enough to easily penetrate the soil and root/peat material, cut around the base of the core tube straight up and down with a serrated knife through the root zone before inserting the core tube into the soil.
25. Depress the core tube to 16 cm depth while continuing to rotate/twist the tube. Take care not to compact/compress the soil inside the tube.
26. To document compaction, measure the distance to the sediment surface on the outside and inside of the core tube. Measurements should be made at the same place on the outside and inside of the core tube to avoid differences in ground height caused by uneven surfaces or vegetation density.
27. Record both measurements on the soil core field data sheet.
28. Core compaction should be 10% or less (< 1.6 cm for a 16-cm core) in most soil types. Highly organic soils (e.g., floating marsh, flooded swamp sites) may have a compaction rate of up to 20%. All caution should be taken to obtain cores with a minimal amount of compaction.
29. Plug or cap the top of the core tube to assure suction. Any head space should not be filled with external water for this application.

30. Dig a narrow trench around one side of the core tube and place a flat, rigid object under the core tube to avoid loss of material upon removal from the marsh.
31. Extrude the entire 16-cm core, including all indigenous water in the core tube, into a pre-labeled gallon size Glad® bag or other airtight container as a composite sample. This container will be used in the laboratory during the drying process and will be heated to 60°C (140°F). It must be able to be heated to this temperature without melting, changing composition, or reacting with the sample.
32. Repeat until three (3) viable cores have been taken and processed.
33. Place all soil samples on ice and transport back to the lab.

Eighteen samples, or three from unsliceable sites, shall be delivered to the contracted soils laboratory within 48 hours of collection. Samples shall be transported and stored on ice (approximately 39°F (4°C)) from collection to delivery.

The soil cores data sheet (Figure 8.4) shall be filled out completely. Naming conventions for cores to be recorded in the “CoreID” field shall be “CRMS\_0000\_S01,” “CRMS\_0000\_S02,” and “CRMS\_0000\_S03.” After the core has been inserted into the soil matrix, measurements of the distance (cm) from the top of the core tube to the soil surface on both the inside and outside of the core tube should be recorded in the appropriate blanks on the data sheet. Additional measurements that are to be noted on the data sheet about each core include the exact length of the core tube being utilized (cm) and the depth of material that was extruded from the core when it was sliced (cm). The latter measurement can be obtained by continuing to extrude the core down to the bottom after it has been sliced, noting the number of 0.5-cm revolutions required to reach the bottom of the core. These measurements will be used to calculate two types of compaction: compaction due to extraction or core sampling, and compaction due to extrusion and core slicing. These numbers will be used to assess core quality. Compaction due to extraction is calculated as:

$$\% \text{ Compaction} = ((\text{INSIDE-OUTSIDE})/(\text{Depth Inserted}))*100$$

and compaction due to extrusion is calculated as:

$$\% \text{ Compaction} = ((\text{Depth Extracted} - \text{Depth Extruded})/\text{Depth Extracted})*100.$$

Compaction due to extraction should be minimized as much as possible by inserting the core tube slowly, using a cutting blade, and using clear acrylic tubing to see inside the core as the core tube is depressed. Other descriptive information about each core should be included on the core data sheet, including site characteristics, soil characteristics, and core method.

### Floating Mat Shear Strength:

A torvane strength tester shall be used to determine the shear strength in floating marsh soils (or similar saturated cohesive soils) either in the laboratory or the field (McGinnis 1997). These instruments measure the torque ( $\text{kg}/\text{cm}^2$ ) required to shear through, or deform, the soil (known as failure). A torvane is composed of a toothed plate (a vane) and a spring-loaded torque meter (driver). The torvane is inserted into a flat-surfaced soil in the field or into a soil sample to the depth of the teeth on the vane ( $\sim 0.5$  cm). The torque, or shear strength, is obtained by rotating the driver with constant pressure (torque) until failure occurs. The torque required to shear the sediment along the vertical and horizontal edges of the vane is a relatively direct measure of the shear strength of the mat. With some torvanes, shear strength must be normalized to the vane constant, which is a function of the vane size and geometry. However, most manufacturers (e.g., ELE International, Humboldt Manufacturing, Durham Geo) produce a handheld torvane that directly returns a measure of shear strength from calibrated springs.

### 8.3. Data Processing

#### 8.3.1 Laboratory Analysis

The following procedures will be used by a contracted laboratory to analyze soil pH, soil salinity (EC), dry bulk density, percent soil moisture, percent organic matter (loss-on-ignition), and wet/dry volume of the collected soil cores. These procedures, which were developed by the Coastal Wetlands Soils Characterization Lab, Department of Agronomy & Environmental Management, Louisiana State University, will provide a standardized procedure for all soil analyses associated with the CRMS project.

##### *Sample Delivery and Storage:*

All soil samples will be delivered to the contracted laboratory on ice in labeled, sealed containers (Glad® brand zipper bags). The chain of custody form (Figure 8.5) will be completed, documenting receipt of samples. All samples will be cold-stored ( $4^{\circ}\text{C}$ ) from the time of receipt until the samples are processed and analyzed.

##### *Analysis Protocols:*

##### Soil pH:

Soil reaction (pH) is affected by the ratio of soil:water, the salt content, time of reaction, and the  $\text{CO}_2$  content. It is therefore necessary to standardize conditions to obtain reproducible results.

##### I. Materials



- 1) Deionized water
- 2) Glassware
- 3) pH meter (ORION 710A)
- 4) Balance (OHAUS TS400)

### II. Procedures

- a. Record soil sample ID number into laboratory log book.
- b. Take a subsample of the soil sample from the container.
- c. Weigh duplicate 20-g samples of fresh soil samples into beakers and record (Wet Sample Weight).
- d. Add 20 cm<sup>3</sup> of deionized water.
- e. Stir for one minute at 30-minute intervals for 1 hour.
- f. Calibrate pH meter before measuring the samples, using pH buffers 4.0 and 7.0. Recheck the meter with pH buffer 7.0 between every ten samples. If the meter does not read 7.0, recalibrate the meter, re-read any suspect previous samples, and proceed with the remaining samples.
- g. Record the pH value after the meter is stable (approximately 1 minute after immersing the electrode).
- h. No soil sample should be destroyed or compromised, as it will be added back to the soil analyzed for bulk density for homogenization and subsequent percent organic analysis.

### III. Calculations

The results of soil pH will be reported based on the average of two replications.

### IV. QA/QC

- 1) Use a stopwatch for stirring the samples (all samples are handled consistently).
- 2) Make sure the labels are correct and the data are recorded in the right position.
- 3) Make sure the samples are already mixed thoroughly.
- 4) Run the two replications of the sample.
- 5) If the difference between the pH values of the two replications (rep1 and rep2) of a sample is greater than 0.5, then repeat the analysis for that particular sample.

#### Soil Salinity (EC):

EC is measured in mS/cm (milliSiemens per centimeter) and gives an indication of soil salinity measured in ppt (parts per thousand). One mS/cm is equivalent to one mmhos/cm (millimhos per centimeter). Various EC meters measure in

different ranges. Some meters even read low enough levels to measure in  $\mu\text{S}/\text{cm}$  (microSiemens per centimeter). It takes 1,000  $\mu\text{S}/\text{cm}$  to equal one  $\text{mS}/\text{cm}$  or one  $\text{mmhos}/\text{cm}$ .

Laboratories commonly make measurements on a 1:1 by weight of soil-to-water slurry, which is the method to be used in the EC analysis. EC analysis will use the same solution which was prepared for pH analysis.

### I. Materials

- 1) Conductivity meter (Thermo Orion 150A+)
- 2) Calibration solutions (12.9  $\text{mS}/\text{cm}$  and 1413 $\mu\text{S}/\text{cm}$ )
- 3) Deionized water

### II. Procedures

10. Record soil sample ID number into laboratory log book.
11. Take a subsample of the soil sample from the container.
12. Weigh duplicate 20-g samples of fresh soil samples into beakers and record (Wet Sample Weight).
13. Add 20  $\text{cm}^3$  of deionized water.
14. Stir for one minute at 30-minute intervals for 1 hour.
15. Record the EC value after the meter is stable (approximately 1 minute after immersing the electrode).
16. No soil sample should be destroyed or compromised, as it will be added back to the soil analyzed for bulk density for homogenization and subsequent percent organic analysis.

### III. Calculations

The results of soil EC will be reported based on the average of two replications.

### IV. QA/QC

3. Follow the procedure described in pH measurement.
4. Calibrate the EC meter between every measurement and check the reading in standard solutions (12.9  $\text{mS}/\text{cm}$  or 1413 $\mu\text{S}/\text{cm}$ ) every 10 samples.
5. If the difference between the EC values of the sample and its duplicate is greater than 0.2 ppt (or 500  $\mu\text{S}$ ), then repeat the analysis for that particular sample.
6. The sequence of reading and time between samples must be consistent.

Bulk Density, Soil Moisture, and Wet/Dry Volume Ratio:

Bulk density, which is a measure of both the organic and inorganic fractions, may be expressed as either wet bulk density (includes the water in the sample) or as dry bulk density (the sample is allowed to dry). However, since the convention is normally to use dry bulk density, this discussion is confined to that variable. It has been shown that soil density is controlled by the amount of mineral material that infiltrates the organic material framework of the highly organic marsh soils (Gosselink and Hatton 1984). This organic material framework appears to have a fairly constant ratio of mass to volume. Dry bulk density values generally range from  $0.05 \text{ g/cm}^3$  to  $1.25 \text{ g/cm}^3$ . In highly organic soils, such as those found in coastal marshes, it is more meaningful to express soil nutrients in terms of volume instead of mass (Clarke and Hannon 1967; Mehlich 1972; Delaune et al. 1979; Rainey 1979). Since vegetation roots invade a given volume of soil as opposed to a given mass of soil, plant biomass shows a better relationship to soil nutrients expressed on a per volume basis as opposed to a per mass basis (Delaune et al. 1979).

For wet/dry volume ratio, all soil samples are stored in the refrigerator and maintained at a constant temperature of  $4^\circ\text{C}$ . It is assumed that all samples are identical and at this temperature the density of water is equal to  $1 \text{ g/cm}^3$ , which means that 1 g of water will have a volume of  $1 \text{ cm}^3$ .

### I. Materials

6. Soil sample of known volume
  - a. Cylinder of radius  $r$  (cm), height  $h$  (cm): Volume ( $V, \text{cm}^3$ ) =  $\pi r^2 h$
7. Drying oven
8. Balance sensitive to 0.01 g
9. Desiccator

### II. Procedures

6. Soil samples will be dried in the laboratory in the containers provided from the field collection. Glad® brand zipper bags will be used to contain all soil samples since the type, brand, and size of the containers used must be consistent over time such that they can withstand a temperature of at least  $60^\circ\text{C}$ . Quart-size bags will be used for sliceable, 4-cm soil samples, and gallon-size bags will be used for 16-cm composite soil samples. In the event that the Glad® brand zipper bag is compromised in transport or elsewhere, an average weight of 100 bags including any labels will be used as the container tare weight (Vessel Weight) for those calculations.
7. Record soil sample number.
8. Weigh vessel + sample (Vessel + Sample<sub>wet</sub>) to nearest 0.01 g to obtain Wet Sample Weight and record.

9. Place vessel + sample in forced-air drying oven set at 60 °C for 48 hours.
10. Remove all samples from the oven (Vessel + Sample<sub>dry</sub>), allow to cool in a desiccator, weigh, and record to obtain Dry Sample Weight.
11. Return all samples to the oven (60 °C) for 6 hours, cool, and re-weigh. If weights are within  $\pm 5\%$  of the original dried weight, proceed to calculations. If weights are  $> \pm 5\%$ , place these samples back into the 60 °C oven for 24 hours, cool, and weigh. Repeat this process until a constant weight is obtained.
12. Record weight to nearest 0.01 g (Dry Sample Weight).

### III. Calculations

3. Wet Sample Weight (g) = (Vessel + Sample<sub>wet</sub>) – Vessel Weight
4. Dry Sample Weight (g) = (Vessel + Sample<sub>dry</sub>) – Vessel Weight
5. Oven Dry Bulk Density (g/cm<sup>3</sup>) = (Dry Sample Weight) / (Volume of Soil Sample)
6. Soil Moisture Content (%) = [(Wet Sample Weight – Dry Sample Weight) / (Wet Sample Weight)] \* 100
7. Wet Soil Volume (cm<sup>3</sup>) = (Volume of Soil Sample) + (Volume of Water)

$$\begin{aligned} \text{Where: Volume of Soil Sample (V, cm}^3\text{)} &= \pi r^2 h \\ &= 324.128 \text{ cm}^3 \\ r &= \text{radius of core} \\ &= 5.08 \text{ cm} \\ h &= \text{height of samples} \\ &= 4 \text{ cm} \end{aligned}$$

8. Dry Soil Volume (cm<sup>3</sup>) = (Volume of Soil Sample) – (Volume of Water)
9. Wet/Dry Volume Ratio = (Wet Soil Volume) / (Dry Soil Volume)

### IV. QA/QC

1. All samples will be dried to a constant weight as a QA/QC check.

#### Percent Organic Content (Loss-on-Ignition, LOI):

Organic matter in soils and sediments is widely distributed in almost all terrestrial and aquatic environments (Schnitzer 1978). Soils and sediments contain a large

variety of organic materials. The determination of organic carbon is an essential part of any site characterization since its presence or absence can markedly influence how chemicals react in the soil or sediment. Organic carbon contents may be used qualitatively to assess the nature of the sampling location or to normalize portions of the analytical chemistry dataset. Loss-on-ignition (LOI) is a common and widely used method to estimate the organic matter content (Henri et al. 2001) and involves the heated destruction of all organic matter in the soil or sediment.

### I. Materials

- c. 2-mm sieve (No. 10)
- d. Ashing crucibles, numbered
- e. Muffle furnace
- f. Analytical balance (0.001-g sensitivity)
- g. Safety gloves (thermal and plastic)
- h. Desiccator

### Procedures

- c. Add all soil that was originally subsampled and used in the pH and soil salinity analyses to the remaining dried soil analyzed for bulk density.
- d. Grind the dried soil sample (above) through a 2-mm (No. 10) sieve screen.
- e. Randomly select 10% of the samples to be analyzed for QA/QC and run replicate analyses.
- f. Record the soil sample ID number, the crucible ID number, and the crucible tare weight into a laboratory log book.
- g. Thoroughly homogenize the ground soil sample.
- h. Weigh approximately 2–3 g of dried and ground soil that has passed through a 2-mm sieve into a clean crucible.
- i. Record the crucible + soil sample weight (Crucible + Soil Wt. B<sub>60</sub>) into a laboratory log book. Note: The value “60” represents the temperature at which the sample was previously dried.
- j. Place crucible + soil into a cool muffle furnace and bring temperature to 550 °C. Once the target temperature has been reached, ash in the furnace for 2 hours.
- k. Remove crucible + soil sample (Crucible + Soil Wt. A<sub>550</sub>) from the furnace using safety gloves. Allow to air-cool slightly, then place in a desiccator (to prevent moisture accumulation). Note: The value “550” represents the temperature at which the sample was ashed.
- l. Once cool, weigh to the nearest 0.01 g and record data in laboratory log book.
- m. Calculate the percent organic matter of the soil sample following the formula below.

### III. Calculations

d. Percent organic matter (% O.M.):

$$\% \text{ O.M.} = \frac{[(\text{Soil Wt. } B_{60}) - (\text{Soil Wt. } A_{550})]}{(\text{Soil Wt. } B_{60})} \times 100$$

Where: Soil Wt.  $B_{60}$  = Weight of soil samples before ashing (previously dried at 60°C)

$$= [(\text{Crucible} + \text{Soil Wt. } B_{60}) - (\text{Crucible})]$$

Soil Wt.  $A_{550}$  = Weight of soil samples after ashing (at 550°C)

$$= [(\text{Crucible} + \text{Soil Wt. } A_{550}) - (\text{Crucible})]$$

#### IV. QA/QC

- A. Replicates of 10% of samples will be run as a QA/QC check.
- B. Calculate the percent difference between the replicate samples selected for QA/QC. If the sample organic content of the replicates is within  $\pm 5\%$  of each other, record the primary reading as the final reading.
- C. If the QA/QC samples are not within  $\pm 5\%$  of each other, repeat the ashing and weighing process for all samples until a constant weight is obtained and the organic content is within  $\pm 5\%$ .

Data validation for these methods consists of checking to be sure that all sample containers are properly labeled and that sample numbers and crucible numbers are double-checked by laboratory personnel during analysis procedures. In addition, the laboratory personnel must be sure to check the labels on the standards before use.

#### *Data Reporting and Transferal:*

Data reporting will be done by the laboratory as soon as the samples are analyzed. A report will be sent to the original contractor that collected the samples which will contain the following:

1. Chain of custody form
2. Values of standards
3. Results of QC checks
4. Analysis results in digital format provided by the CPRA (Figure 8.6).
5. Discussions of any problems along with steps taken to address them.

#### **8.3.2 Data Entry and QA/QC**

**DATA ENTRY (PHASE I):** The contractor will obtain the sample analysis data in the appropriate format from the contracted laboratory. Data will be checked for completeness and consistency. Ensure that the data are within a logical range for each parameter measured (Table 8.1). If any data are deemed illogical,

contact the contracted laboratory and resolve the discrepancy. Verify that the soil cores data sheet is complete.

**Table 8.1.** Soil parameters to be measured by the lab and their associated units with acceptable ranges.

Parameter	Acceptable Range
Soil pH	0 to 14
Soil salinity (EC)	0 to 90 mS/cm
Soil salinity (EC)	0 to 60 ppt
Bulk density	0.01 to 2.0 g/cm <sup>3</sup>
Soil moisture	0 to 100%
Percent organic matter (LOI)	0 to 100%
Wet volume	324.29 cm <sup>3</sup> or 1297.17 cm <sup>3</sup>
Dry volume	less than wet volume (cm <sup>3</sup> )

**QUALITY ASSURANCE / QUALITY CONTROL (PHASE II):** Once the data from the laboratory has been checked and accepted by the contractor, wet pH, dry pH, soil salinity (ppt), bulk density (g/cm<sup>3</sup>), soil moisture (%), percent organic matter (%), and the calculated wet/dry volume ratio should be graphed as a soil profile with depth on the y-axis and the mean value  $\pm$  standard error of the three cores from each site on the x-axis. The variability within the three cores for a site at a depth should be low (less than 5%). If not, re-check data from the laboratory for correctness. Verify that the contracted soils laboratory followed the appropriate QA/QC protocols. A recommended QA/QC checklist template is found in Figure 8.7. However, printing and completing the QA/QC checklist is not a requirement nor is it a deliverable.

Once the data have been fully QA/QC'd, the .xls file containing the analysis results (Figure 8.6) shall be saved in a comma-delimited format with one file for each CRMS site.

## 8.4 Deliverables

The following deliverables shall be placed on the CPRA FTP site in the “Soil Properties” folder:

- The analysis results in both .xls and comma delimited format (Figure 8.6).

- The soil cores data sheet in .pdf format (Figure 8.4).

- The chain of custody form in .pdf format (Figure 8.5).

The original sediment cores data sheet and chain of custody form shall be delivered to the CPRA within one week of electronic data delivery.



## 8. Soil Properties

Station ID	Group	Sample Date (mm/dd/yyyy)	Core # (1-3)	Sample Depth (cm)	Wet Soil pH (pH units)	Dry Soil pH (pH units)	Soil Specific Conductance (uS/cm)	Soil Salinity (ppt)	Soil Moisture Content (%)	Bulk Density (g/cm3)	Organic Matter (%)	Wet Volume (cm3)	Dry Volume (cm3)	Organization	Personnel	Comments
CRMS0612-S01		04/28/2005	1	0 to 4										3001 Inc	J. Smith	core contained tar
CRMS0612-S01		04/28/2005	1	4 to 8												
CRMS0612-S01		04/28/2005	1	8 to 12												
CRMS0612-S01		04/28/2005	1	12 to 16												
CRMS0612-S01		04/28/2005	1	16 to 20												
CRMS0612-S01		04/28/2005	1	20 to 24												
CRMS0612-S01		04/28/2005	1	0 to 16												
CRMS0612-S01		04/28/2005	2	0 to 4												
CRMS0612-S01		04/28/2005	2	4 to 8												
CRMS0612-S01		04/28/2005	2	8 to 12												
CRMS0612-S01		04/28/2005	2	12 to 16												
CRMS0612-S01		04/28/2005	2	16 to 20												
CRMS0612-S01		04/28/2005	2	20 to 24												
CRMS0612-S01		04/28/2005	2	0 to 16												
CRMS0612-S01		04/28/2005	3	0 to 4												
CRMS0612-S01		04/28/2005	3	4 to 8												
CRMS0612-S01		04/28/2005	3	8 to 12												
CRMS0612-S01		04/28/2005	3	12 to 16												
CRMS0612-S01		04/28/2005	3	16 to 20												
CRMS0612-S01		04/28/2005	3	20 to 24												
CRMS0612-S01		04/28/2005	3	0 to 16												

**Figure 8.6.** Soil core data format.

SEDIMENT CORES QA/QC CHECKLIST		
Project / Site Number: _____ Date cores collected: _____ QA officer: _____		
Data Collector: _____ Date approved: _____		
DNR/USGS QA Officer: _____ Date: _____		
		QA Officer's Initials and Date
1	Was a field trip report generated ? <b>Y / N</b> COMMENTS:	
2	Was the field sheet checked for completeness? <b>Y / N</b> COMMENTS:	
3	Were the cores sliced in the field? If not, describe problems. <b>Y / N</b> COMMENTS:	
4	Was there more than 10% compaction? If so, describe conditions and attempts made. <b>Y / N</b> COMMENTS:	
5	Were core samples transported to the contracted soils lab with 48 hours? <b>Y / N</b> COMMENTS:	
6	Were the data received from the contracted soils lab? <b>Y / N</b> COMMENTS:	
7	Were the data QA/QC'd for completeness and logical values? <b>Y / N</b> COMMENTS:	
8	Were data graphed? Was there more than 5% variation between samples for each depth? <b>Y / N</b> COMMENTS:	
9	Were data uploaded to the ftp site? <b>Y / N</b> COMMENTS:	
10	Were all spreadsheets (received from the lab and created by the contractor) delivered to LDNR? <b>Y / N</b> COMMENTS:	
		Final QA Officer's Initials and Date

**Figure 8.7.** Example of a soil cores data QA/QC checklist.

## **9. IMAGERY**

### **9.1. Aerial Photography**

Color-infrared photography will be acquired at each 1-km<sup>2</sup> CRMS-*Wetlands* site to provide a site-specific assessment of land and water coverage trends. An unsupervised classification based on a 50-class assignment, 0.950 convergence threshold, and a maximum of 10 iterations will be performed on the appropriate aerial photography for each site. The new image will be analyzed and interpreted and the original 50 classes will ultimately be combined into two classes, land and water. Unless otherwise noted as a specific preliminary condition, all vegetation such as scrub-shrub, emergent vegetation, and forested areas will fall under the land classification, while open water, nonvegetated mud flats, and aquatic beds will be characterized as water. After classification is complete, an accuracy assessment will be performed to determine a percent accuracy level of the land/water classification. Using the image processing software, no less than 100 points are randomly generated and distributed throughout the image, which is then identified, labeled, and compared to the original classification. After all points are identified and compared to the original classification, an accuracy percentage is calculated. The final image will be submitted to the NWRC (National Wetlands Research Center) photointerpreter and the CPRA monitoring manager(s), as well as to other members of the CWPPRA team for review to ensure proper classification. All edits and suggestions will be considered and amended where appropriate.

After accuracy has been determined, maps depicting the analysis with acreage amounts overlaid onto base photography will be created in report-compatible (8.5 x 11 in.) and presentation (display size) formats. Each will follow standard cartographic procedures. When two or more land/water analyses are to be compared for change in land acreage, the GIS analyst will create a composite file that congregates the different years of data. Four categories of data will be displayed on a composite image: land and water areas that remained unchanged between the two images, as well as classes depicting the areas where land loss and land gain occurred.

The detailed protocol for color-infrared photography acquisition, interpretation, digitization, and statistics can be found in the "Quality Management Plan for Coastal Wetlands Planning, Protection, and Restoration Act Monitoring Plan" revised in June of 2000.

## 9.2 Satellite Imagery

Coastwide satellite imagery will be acquired every three years at a spatial resolution suitable for regional assessment of land and water trends. Landsat Thematic Mapper (TM) multi-spectral imagery will be used for the initial assessments, although other imagery may be incorporated as newer satellites are deployed. Imagery will be acquired during clear weather conditions after frontal passages during the fall, although some later winter imagery may be needed to minimize the presence of aquatic vegetation in fresh marshes. Landsat imagery will be acquired in FASTL-7A format, and geocoded, with full terrain correction. All imagery will be radiometrically corrected to normalize digital numbers for between-image comparisons over time. Landsat Imagery will be classified with the same classification methodology used to develop the Louisiana Coastal Area Study classified Landsat land and water datasets. Each image will be classified individually to identify land and water. A classification accuracy assessment, using at least 150 randomly generated and distributed points, will be conducted on each classified scene, resulting in an overall accuracy estimate for the classified image. The separate classified land and water images will be mosaicked to produce a seamless coastal classified land and water dataset. The coastwide dataset will be compared to the most recent land and water dataset to identify changes in land and water distribution during the collection interval. Tables summarizing land and water area changes by basin and province, and spatial change datasets and maps highlighting land and water changes will be produced for CPRA and CWPPRA review and distribution.

Improvements in satellite technologies will be continually assessed over time for potential application in land and water trend analysis. Reductions in cost and improvements in accuracy may allow one high-resolution satellite image to meet the site-specific and regional assessment requirements of the CRMS-*Wetlands* program.

## REFERENCES

- Andrejko, M.J., F. Fiene, and A.D. Cohen. 1983. Comparison of ashing techniques for determination of inorganic contents of peats. *In* P.M. Jerret, *editor*. *Testing of Peats and Organic Soils*. ASTM STP 820. American Society of Testing Materials, Philadelphia, PA, pp. 5–20.
- Avery, T.E. and H.E. Burkhardt. 1994. *Forest Measurements*. 4th ed. McGraw-Hill, NY. 408 pp.
- Bass, A.S., C.F. Robertson, and W.K. Rhinehart. 2003. Office of Coastal Restoration and Management quality management plan: 2003. Louisiana Department of Natural Resources, Baton Rouge, LA. 98 pp.
- Bohn, C.C. 2001. Guide for fabricating and installing shallow ground water observation wells. USDA Research Note RMRS-RN-9. 5 pp.
- Brady, N.C. and R.R. Weil. 2002. *The Nature and Property of Soils*. 13th ed. Prentice Hall, NY. 960 pp.
- Cahoon, D.R., J.C. Lynch, P. Hensel, R. Boumans, B.C. Perez, B. Segura, and J.W. Day, Jr. 2002a. A device for high precision measurement of wetland sediment elevation: I. Recent improvements to the sedimentation-erosion table. *Journal of Sedimentary Research* 72: 730–733.
- Cahoon, D.R., J.C. Lynch, and R.M. Knaus. 1996. Improved cryogenic coring device for sampling wetland soils. *Journal of Sedimentary Research* 66:1025–1027.
- Cahoon, D.R., J.C. Lynch, B.C. Perez, B. Segura, R. Holland, C. Stelly, G. Stephenson, and P. Hensel. 2002b. A device for high precision measurement of wetland sediment elevation: II. The rod surface elevation table. *Journal of Sedimentary Research* 72: 734–739.
- Couvillion, B.R., J.A. Barras, G.D. Steyer, W. Sleavin, M. Fischer, H. Beck, N. Trahan, B. Griffin, and D. Heckman. 2011. Land area change in coastal Louisiana from 1932 to 2010. U.S. Geological Survey Scientific Investigations Map 3164, scale 1:265,000. 12 p. pamphlet.
- CPRA 2011. A contractor's guide to minimum standards required by the Coastal Protection and Restoration Authority: For contractors performing GPS surveys and determining GPS derived orthometric heights within the Louisiana Coastal Zone. Coastal Protection and Restoration Authority, Operations Division, Baton Rouge, LA. 40 pp.

- Clarke, L.D. and N.J. Hannon. 1967. The mangrove swamp and salt marsh communities of the Sydney district. *Journal of Ecology* 55:753–771.
- DeLaune, R.D., R.J. Buresh, and W.H. Patrick, Jr. 1979. Relationships of soil properties to standing crop biomass of *Spartina alterniflora* in a Louisiana salt marsh. *Estuarine Coastal Marine Science* 8:477–487.
- Feijtel, T.C., R.D. DeLaune, and W.H. Patrick, Jr. 1988. Seasonal pore water dynamics in marshes of the Barataria Basin, Louisiana. *Soil Science Society of America Journal* 52:59–67.
- Folse, T.M. and J.L. West. 2005. A standard operating procedures manual for the Louisiana Department of Natural Resources, Coastal Restoration Division: Methods for data collection, quality assurance/quality control, storage, and products. Louisiana Department of Natural Resources, Baton Rouge, LA. 226 pp.
- Gagliano, S.M., K.J. Meyer-Arendt, and K.M. Wicker. 1981. Land loss in the Mississippi River deltaic plain. *Transactions of the Gulf Coast Association of Geological Societies* 31:295–300.
- Gosselink, J.G. and R. Hatton. 1984. Relationship of organic carbon and mineral content to bulk density in Louisiana marsh soils. *Soil Science* 137(3):177–180.
- Hargis, T.G. and R.R. Twilley. 1994. Improved coring device for measuring soil bulk density in a Louisiana deltaic marsh. *Journal of Sedimentary Research* 3:681–683.
- Henri, O., A.F. Lotter, and G. Lemcke. 2001. Loss on ignition as a method for estimating organic and carbonate content in sediments: reproducibility and comparability of results. *Journal of Paleolimnology* 25:101–110.
- McGinnis II, T.E. 1997. Factors of soil strength and shoreline movement in a Louisiana coastal marsh. M.S. Thesis, University of Southwestern Louisiana, Lafayette, LA. 79 pp.
- McKee, K.L., I.A. Mendelssohn, and M.W. Hester. 1988. Reexamination of pore water sulfide concentrations and redox potentials near the aerial roots of *Rhizophora mangle* and *Avicennia germinans*. *American Journal of Botany* 75:1352–1359.
- Mehlich, A. 1972. Uniformity of soil test results as influenced by volume weight. *Communications in Soil Science and Plant Analysis* 4(6):475–486.
- Meriwether, J.R., W.J. Sheu, C. Hardaway, and J.N. Beck. 1996. Coring sampler for chemical analyses of soft sediments. *Microchemical Journal* 53:201–206.

- Mitsch, W.J. and J.G. Gosselink. 1993. *Wetlands*. 2nd ed. John Wiley & Sons, NY. 722 pp.
- Mueller-Dombois, D. and H. Ellenberg. 1974. *Aims and Methods of Vegetation Ecology*. John Wiley and Sons, NY. 547 pp.
- Phillips, L.A. 2002. Vertical accretion and marsh elevation dynamics on the Chenier Plain, Louisiana. M.S. Thesis, University of Louisiana-Lafayette, Lafayette, LA.
- Rainey, G.B. 1979. Factors affecting nutrient chemistry distribution in Louisiana coastal marshes. M.S. Thesis, Louisiana State University, Baton Rouge, LA.
- Rich, P. M., J. Wood, D. A. Vieglais, K. Burek, N. Webb. 1999. HemiView Manual Revision Number: 2.1. Delta-T Devices, Ltd.
- Schnitzer, M. 1978. Humic substances: Chemistry and reactions. *In* M. Schnitzer and S.U. Khan, *editors. Soil Organic Matter*. Elsevier Scientific Publishing Co., NY. pp. 1–64.
- Sprecher, S.W. 2000. Installing monitoring wells/piezometers in wetlands. ERDC TN-WRAP-00-02. 17 pp.
- Steyer, G.D., R.C. Raynie, D.L. Steller, D. Fuller, and E. Swenson. 1995. Quality management plan for the Coastal Wetlands Planning, Protection, and Restoration Act monitoring program. Open-File Series No. 95-01. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division. 108 pp.
- Steyer, G.D., C.E. Sasser, J.M. Visser, E.M. Swensen, J.A. Nyman, and RC. Raynie. 2003. [A proposed coast-wide reference monitoring system for evaluating wetland restoration trajectories in Louisiana](#). Environmental Monitoring and Assessment 81:107–117.
- Swenson, E.M. 1982. A report on the Catfish Lake, Louisiana, backfilling study. Prepared for National Marine Fisheries Service, Southeast Region, St. Petersburg, FL. Baton Rouge: Louisiana State University, Coastal Ecology Laboratory. Coastal Ecology Publication LSU-CEL-82-25. 44 pp.
- Visser, J.M. and C.E. Sasser. 1998. 1997 Coastal vegetation analysis. Louisiana State University: Coastal Ecology Institute. Baton Rouge, LA.